THE PLANT DISEASE REPORTER

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so.

(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your references carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestion of McCallan et al. in Phytopathology (45 (6): 295-302. 1955).

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

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(10) The MULTILITH PLATES from which reprints can be made will be sent if requested at the time the article is submitted. The press size of these plates used for the Reporter is designated as small -- maximum image 9 1/2 by 13 inches, maximum paper size 9 3/4 by 14 inches -- for Model 1250. Most of the Experiment Stations have this type of multilith machine.

ACCEPTANCE OF MANUSCRIPTS

The increase in the volume of pertinent material offered for publication in the Plant Disease Reporter has made it necessary to limit the subject matter and the length of articles accepted. The subject matter should emphasize new things in plant pathology, such as new records of disease occurrence, serious outbreaks and epidemics, conditions affecting development of plant diseases, techniques of investigation including instrumentation, new discoveries in control including new materials and their evaluation. Manuscripts will be limited to 15 double-spaced typed pages. Insofar as possible, material should be presented as graphs rather than tables. Papers cannot be accepted for publication that report routine control experiments, reviews, bibliographies without annotation, results of routine surveys, mere summaries or lists of plant diseases. By following this procedure we hope to continue publishing all articles promptly.

Paul R. Miller

Manuscripts for and correspondence about this publication should be sent to:

PLANT DISEASE REPORTER
Mycology and Plant Disease Reporting Section
Crops Protection Research Branch
Plant Industry Station
Beltsville, Maryland

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MOVEMENT OF AIR IN A RICE PADDY AS INDICATED BY COLORED SMOKE

E. P. Van Arsdel[1], E. C. Tullis[2], and J. D. Panzer[3]

Abstract

Colored smoke released in and around rice paddies gave indications of possible paths of fungus spore movement. Smoke drift was recorded by serial photographs of sketches. Smoke release was about 2 minutes for each observation. Heat from smoke production rarely disturbed air circulation. With daytime winds, smoke released at 0 feet and 12 feet above ground moved downwind at the level of release; however, spiralling was often noted. In sunlight, updrafts were produced over locally-warmed places. These were at levees in the flooded paddies, bare soil in sod, and sunny sides of earth mounds. A windbreak of Casuarina equisetifolia L. developed updrafts on the sunny side and downdrafts on the shady side. The down-flowing air on the shady side flowed under the trees and up the sunny side making a circulation cell. Two-foot-wide openings in 4-foot rice had downdrafts with a slow subsequent diffusion of the smoke through the rice. In still air in pre-sunrise inversion conditions there was wind drift of about 100 feet per minute at a 25-foot level. Night and pre-dawn movements were considered most important in the spread of several pathogenic fungi.

As an approach to the problem of how fungus spores might be carried by currents in a rice paddy, red, green, and yellow smoke grenades of the standard U. S. Army type were released at various times to observe patterns of air movements. This work was performed largely on muck soil, but supplemental studies were made on white sand. The research areas were about 27° North Latitude.

Both color and black-and-white photographs were made, but color film was much better for tracing the different colored smokes upon synchronous release from various release points. Infra-red film gave only slightly better results than standard black-and-white films. Anscochrome film exposed at film speeds of 64 and 128 A.S.A. and then force-processed gave the best record of exposures at dawn.

The winds blew quite regularly during the day and generally from the southeast; apparently the air was calm at night. Wind speed and direction were constantly recorded by cup anemometers and weather vanes. These were located at 6 feet and 15 feet above the ground level of the rice paddy. Daytime winds arose at about 8 or 9:00 A. M. and reached a peak of 10 to 20 miles per hour near 2:00 P. M. Constant day and night winds blowing more consistently in one direction occurred as hurricanes passed by. These winds blew counter-clockwise around the hurricane center. Most commonly, the hurricane winds blew from the north as the storms passed to the east. Afternoon thundershowers usually produced occasional gusts of greater than 25 miles per hour and often greater than 32 miles per hour, the limit of our recording equipment.

The weather vanes at 6 feet and 15 feet at times recorded different wind directions. Sometimes 90° or more difference was noted at the two levels. Figure 1 shows the movement of smoke from a smoke grenade set off on June 19, 1955. It illustrates part of the reason for the

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wide range of wind as it shifts from one angle to another, and why different directions can be recorded at the two different levels at the same time. The air movement on this afternoon was the prevailing east-southeast wind, disturbed somewhat by small scattered thundershowers in the vicinity. The red grenade was set off on the west cross levee when the rice was 40 inches high. The smoke, indicating the movement of the air, erupted upward and over in a 30-foot arc. It continued to roll over, completing a 30-foot loop rolling westward over the ground, and then it shifted to the south, producing a helix 30 feet in diameter with its axis to the southwest. After this a clockwise rotating helix with its axis to the west was produced as a new mass of air moved the whole pattern to the west. The original helix with the southwest axis was rolling on in its own air mass ahead of the east-west helix so that a helix with a 45° bend in its axis was produced. The next air mass produced a new helix with its axis pointing northwest as a mass seemed to move to the northwest. At this time there were three bends in the helix axis; at the close of the 2 minutes of smoke release from the grenade the smoke pattern resembled a great snake winding out of the west side of the paddy with its rotary winds spinning within it. The observation shows a very complex wind structure with countless winds within winds. The principal movements all seemed to be greater- or lesser-sized rotating movements. This movement is reminiscent of the "looping" type movement noted for super-adiabatic lapse-rate conditions in other smoke studies[4]. This pattern has winds blowing in opposite directions at the 30-foot level and at the 3-foot level. Spores carried by such a wind could be deposited in isolated spots.

Such spiral movements were not the rule; often, smoke released at ground level and at 12 feet above the ground moved downwind at the level of release, gradually mixing only after travelling for several hundred feet.

A spot of dry soil such as a levee in a flooded paddy absorbs heat at the surface and produces warmer air over the dry soil during the day. Updrafts occur over such places. A spot of bare soil (in this case white sand) in a grassy area also produces a considerable updraft as shown in Figure 2.

A series of color pictures made from an airplane showed the movement of smoke across the rice paddy on white sand. The smoke of three grenades (to give a big volume of smoke) showed a horizontal movement across the water and then a sudden upturn at a right angle in the updraft over the warm slope of the heap of soil and rubble piled from land clearing. This movement is diagramed in Figure 3.

A windbreak of a single row of trees produced an interesting wind effect. Figure 4 is a diagram of the end of a row of horsetail casuarina trees showing this situation. The diagram was made from a color photograph. A red grenade was set off 15 feet from the left side of the windbreak, a yellow grenade about 15 feet to the right. The camera was facing south so that the morning sun (10:00 A. M.) was shining from the east on the left side. From this diagram it can be seen how the red smoke (cross-hatched) moved up on the sunny side of the trees and then was replaced by the yellow smoke (stippled) blowing through from the shady side of the tree. The yellow smoke flowed right under the trees, making a complete circulation cell around the trees as the red moves over the top and down the shady side. The effects of the windbreak extend beyond the cell illustrated, because such a row of trees makes an "air bump" extending approximately 200 feet into the air; the "air bump" is very noticeable when flying over the row of trees in a small plane. In this example the general wind movement was from the east to the west.

A small opening (about 2-feet-wide) left in the planting of 4-feet high rice at the corner turns exhibited a downdraft that took up a great deal of smoke and slowly released it as it spread out through the rice. Such an opening is cool and had a downdraft because it is shaded from incoming solar radiation much of the day while being cooled by outward long-wave radiation from the earth through the opening.

The studies made at dawn were of great interest because they indicated probable occurrences at night when outward heat radiation is present and incoming solar radiation is absent. Night times were of particular interest because many pathogenic fungi sporulate at night as was shown with the spore collector described by the authors in Phytopathology[5].

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[4]Meteorology and Atomic Energy. 1955. United States Weather Bureau. Washington, D. C.
[5]Panzer, J. D., E. C. Tullis, and E. P. Van Arsdel. 1957. A simple 24 hour spore collector. Phytopathology 47: 512-514.

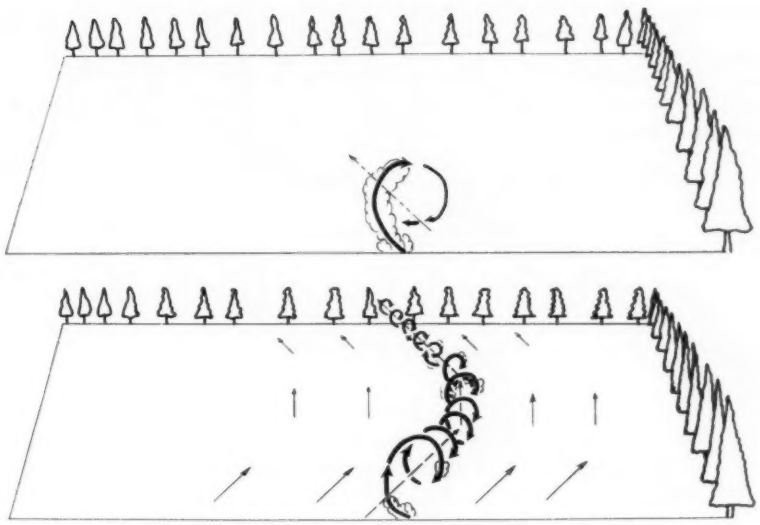

FIGURE 1. Smoke movement from a grenade set off on a warm sunny afternoon. Heavy arrows indicate specific movements, light arrows mass movements.

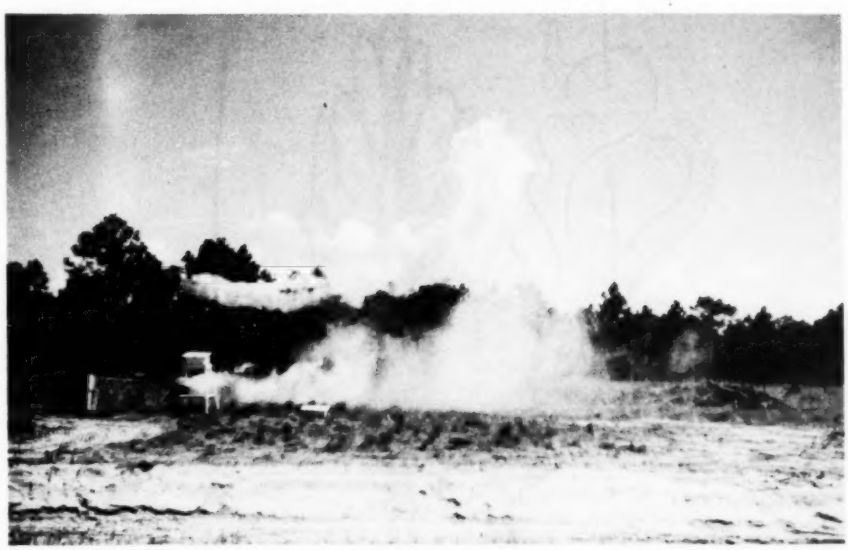

FIGURE 2. Smoke showing updraft over bare soil surrounded by grass (sunny afternoon).

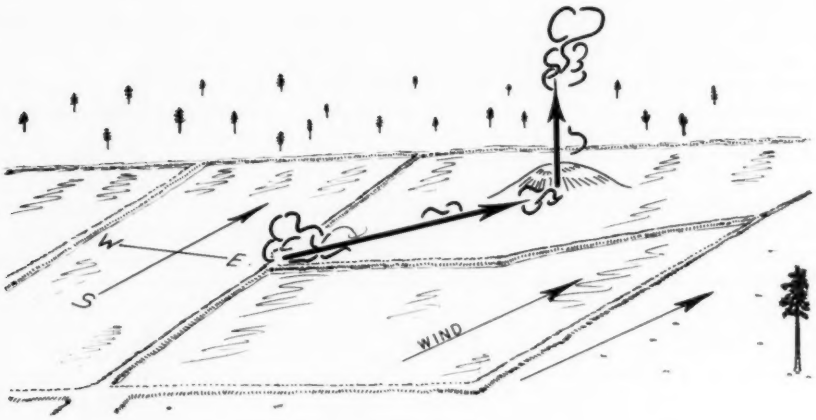

FIGURE 3. Diagram made from color aerial photograph showing movement of smoke with strong updraft over south slope of a rubbish heap. About noon on a warm sunny day.

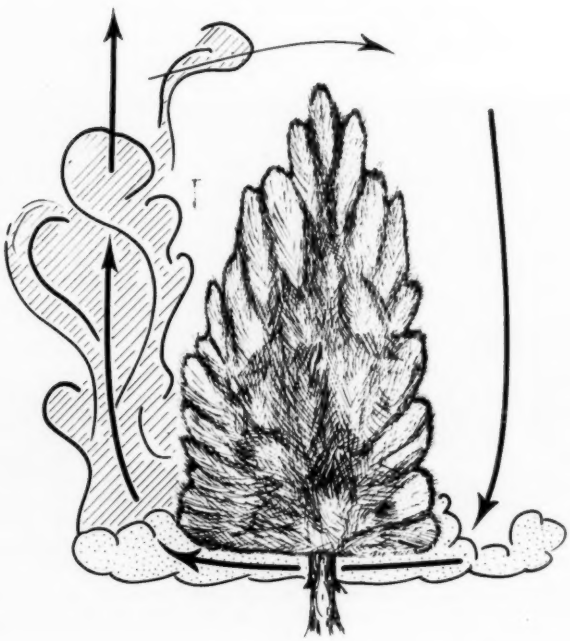

FIGURE 4. Smoke movement at 10:00 A. M. (looking south) on a sunny morning. Shaded area is red smoke released east (left) of trees, dotted area is yellow smoke released west (right) of trees. Diagram from a color photograph.

At dawn, even though the air looked calm, there was drift of about 100 feet per minute. In this relatively still air the heat of combustion seemed to cause the smoke to rise and the warm air to "slide" into the least dense (warmest) level at the inversion layer (about 25 feet above the ground).

While no conclusions relating disease-spread to air currents are presented here, the method of study seems to offer considerable promise in relating the usual paths of fungus spread to paths of air movement. In earlier studies, disease-spread had been correlated with air movements during specific short periods of weather favorable to infection.

UNITED STATES ARMY CHEMICAL CORPS, FORT DETRICK, FREDERICK, MARYLAND

CEREAL RUST EPIDEMIOLOGY AND AEROBIOLOGY IN KANSAS IN 1957[1]

S. M. Pady and C. O. Johnston[2]

Summary

The long, cool, moist spring of 1957 in Kansas was marked by the third heaviest recorded epiphytotic of leaf rust and by moderately heavy infections of stem rust of wheat and crown rust of oats. Stripe rust was found on Kansas wheat for the first time in history. Heavy spore showers, frequent rains, and favorable temperatures resulted in extensive rust development with leaf rust causing an estimated 10 percent loss, stem rust of wheat 3 percent, crown rust of oats 5 percent, and stem rust of oats 1 percent loss.

For the past few years the development of cereal rusts, especially the wheat rusts, has been carefully followed. Particular emphasis has been placed on the determination of the first appearance of rust spores in the air, first appearance of rust in fields, onset of development, number and intensity of spore showers, environmental factors, and estimated losses. The crop year of 1956-57 was marked by extremes in both weather conditions and rust development. The fall of 1956 was very dry, with subnormal moisture through the winter. At the end of March the drouth ended, and from that time to harvest rains were frequent and adequate. In southeast Kansas heavy losses of grain occurred in wet fields, resulting from heavy precipitation at harvest time. Conditions were unusually favorable for leaf rust, Puccinia rubigo-vera tritici Wint. (P. recondita Rob. ex Desm. f. sp. tritici), and a major epiphytotic occurred, the third worst in the history of Kansas agriculture. Stem rust, P. graminis Pers. f. sp. tritici Eriks. & Henn., developed late, causing an estimated loss of 3 percent. Stripe rust of wheat, P. striiformis West. (P. glumarum (Schmidt) Eriks. et E. Henn.), a cool weather rust found principally in mountainous or seacoast locations, was found for the first time in Kansas. An account of the stripe rust has already been published[3]. This paper reports the observations made on the other two wheat rusts and on other cereal rusts.

FALL AND WINTER CONDITIONS

The fall of 1956 was extremely dry in the western third of Kansas and much of the acreage intended for wheat was not sown to that crop. Plants in some fields did not emerge at all, while in many fields seedlings did not emerge until March and failed to make a crop. Others were sown so late that stands were thin or irregular and the plants lacked vigor. Much of the acreage of small late plants blew out in the heavy dust storms of February, March, and April. Ultimately nearly all Kansas wheat fields on dry land in the area from Dodge City west and Goodland south were either plowed up or blown out. About all of the wheat left in that part of Kansas was in irrigated fields.

In central Kansas conditions at seeding time were somewhat more favorable and most wheat emerged to good stands, although many fields were sown late. There was, therefore, considerable variation in size and vigor of plants.

In the eastern third of the State winter wheat was in excellent condition throughout the fall and winter, although there was less top growth than usual in most fields. The plants, though small, were healthy, vigorous, and well-rooted.

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[1]Contribution No. 516, serial No. 668, Department of Botany and Plant Pathology, Kansas Agricultural Experiment Station, Manhattan.

[2]Respectively, Head, Department of Botany and Plant Pathology, Kansas State College, and Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, located at Kansas State College.

[3]Pady, S. M., C. O. Johnston, and C. T. Rogerson. 1957. Stripe rust of wheat in Kansas in 1957. Plant Dis. Reptr. 41: 959-961.

The winter of 1956-57 was extremely dry and mild. There were only two brief periods of subzero weather, both in January, and there was sufficient snow cover for protection of the wheat crop each time. There was, therefore, no observable winterkilling of wheat. Temperatures reached -1° F on January 9 and 10 and -4° F on January 30 and 31 in Manhattan.

Severe dust storms occurred in central Kansas on March 11, 12, 13, and 14. The drouth finally was broken by rains that began March 17. From then on light to moderate rains fell at frequent intervals during the remainder of March and continued on into the growing season. Excessive rains fell in southeastern Kansas as the crop neared maturity, resulting in wet fields which prevented combining and caused total losses in many fields.

AIR-BORNE RUST SPORES IN THE FALL AND WINTER, AND FALL RUST INFECTIONS

Spore traps used in these studies consisted of microscope slides coated with a very thin layer of silicone (DC-4), located on the roof of a building on the Kansas State College campus and mounted at an angle of about 45° at one end of a wind vane, which kept the slide headed into the wind. Spore traps were first set out September 15 and were replaced daily, with a few exceptions, through most of October. Frosts occurred in the State on October 20 and sampling was discontinued on the 26th. The presence of leaf and stem rust spores is recorded in Table 1.

Table 1. Stem rust (SR) and leaf rust (LR) spores from gravity slides exposed 24 or 48 hours on top of Willard Hall, Kansas State College campus, calculated on square foot basis.

Date	LR	SR	Temperature		Wind	Precipitation
			Maximum	Minimum		
Sept. 15, 16	--	T	94, 99	58, 55	NE	T
17	--	-	83	59	NE	
18	--	T	95	54	SSW	
19	--	710	87	52	NE	
20	--	T	92	51	SE	
21	--	-	101	72	SW	
22, 23	710	1421	95, 85	67, 53	NNE	.01
24	--	-	89	49	SW	
25	--	-	92	53	SW	
26	--	-	95	47	WSW	
27	--	-	96	50	WSW	
28	--	-	95	68	S	
29, 30, 31	--	-	81, 76, 95	55, 38, 52	NE	T
Oct. 2	--	T	88	49	NE	
3	--	-	92	44	SE/NW	
4	--	2485	82	59	NE	
5	--	T	94	42	SE	
6, 7	--	1776	79, 80	51, 33	N	
8	--	710	85	56	W/NE	
9	--	-	69	47	NE	
10	--	T	83	47	SE	
11	--	-	89	63	S	
12	--	-	90	68	SW	
13, 14	--	-	85, 76	72, 56	SW	1.33
15	--	T	73	55	SW	T
16	--	T	82	49	NE	
17	--	1421	82	52	NE, SE	
18	--	-	81	53	E	
19	--	-	77	48	S	
20, 21	--	-	65, 75	54, 43	NW	.01
22	--	-	79	42	SW	
23	--	-	77	39	S	
24	--	-	80	55	SE	
25	slide lost		73	43	S	
26	--	T	74	31	S	

Leaf rust spores were very scarce in the air during this period, occurring only once, on October 22-23, and then in low amounts. Stem rust spores were present on only 15 of the slides, as traces on 9 and in low numbers on the remainder. It is of interest that on 9 of the days when stem rust spores were present the wind was from the north, indicating that at this time of year there is a definite southerly movement of rust spores.

The dry fall was generally unfavorable for infection and only occasional rust was found on planted wheat. No rust was observed on a field trip October 11-12 through central Kansas. A sample of large volunteer wheat plants brought in from eastern Kansas on October 12 had old lesions of both stem and leaf rust. In general, there was very little inoculum in the air and very light infections of rust in the field. There was no evidence of overwintering of any of the cereal rusts in any part of the State.

AIR-BORNE SPORES AND SPRING EPIDEMIOLOGY OF LEAF RUST

Spring exposure of adhesive-coated slides was started March 28 for 24-hour periods, except over weekends when slides were left out for 48 hours. Leaf rust spores were first recorded April 18 (Fig. 1) as compared with April 14 and May 7 in the two previous years. The first rust to be found in the field was on April 25, when single pustules of leaf rust were found on wheat in several counties in central Kansas. Presumably these were from the inoculum brought in on April 18, although it is possible that spore inoculum could have been carried into the southern and central parts of the State earlier. By April 30 leaf rust primaries were rather general over the State. Beginning about May 7, leaf rust spores were more numerous on the slides. May 8-15 was a favorable infection period and spores were becoming more numerous. Frequent rains occurred during the first half of May (Fig. 1) but the weather in general was cool, and through May the buildup was very slow. Heavy spore showers occurred May 20, 25, 26, and 28.

Throughout May and June precipitation was above average and temperatures were below average. The following records, taken from the monthly Climatological Record of the Weather Bureau for Kansas, are typical of this period.

	Temperature in ° F		Precipitation in inches	
	Departure from normal		Departure from normal	
	May	June	May	June
Topeka	-0.5	-0.8	-0.6	+0.69
Wichita	-1.3	-2.6	+3.78	+5.47
Concordia	-1.8	-2.0	+1.85	+0.14
Goodland	-3.6	-1.6	+3.31	-0.3
Dodge City	-2.2	-2.8	+0.83	+1.37

These unusually favorable conditions, plus the presence of numerous spore showers, provided rather extensive infection periods, which are indicated on Figure 1 by a heavy line in the upper frame. The figures given for the Manhattan area indicate that there were six periods favorable for infection, varying from 1.5 to 13 days. An unusually long infection period occurred from June 8 to July 1, marked by precipitation on all but 7 days (Fig. 1).

During the first week of June there was a tremendous surge of leaf rust infection. From June 5-7 numbers of rust spores in the air increased sharply, reaching a peak on June 7 when the maximum number of spores for the season was recorded, a record 536,405+ spores per square foot for 24 hours. This was a minimum reading, as rains had occurred during this period and some spores had been washed off. Most of the spores had germinated on the slide. This extremely heavy spore shower, followed by a period of heavy rains and favorable temperatures, resulted in a major epiphytotic of leaf rust in eastern Kansas by June 10. Infections were so heavy that in many instances the flag leaves were destroyed. During the next 2 weeks leaf rust spores continued to be abundant in the air with heavy spore showers on June 21 and 22. Unusually heavy rains through June made conditions fair-to-good for continued rust development in central and western Kansas. Meanwhile, leaf rust had spread westward and ultimately became epidemic on all wheat in the State except in the south central counties where the plants had been defoliated earlier by Septoria tritici or where early or resistant varieties were grown. It has been estimated that the loss from leaf rust during 1957 was at least 10 percent, which is the highest since 1949 when the loss was estimated at 10 percent also. Only

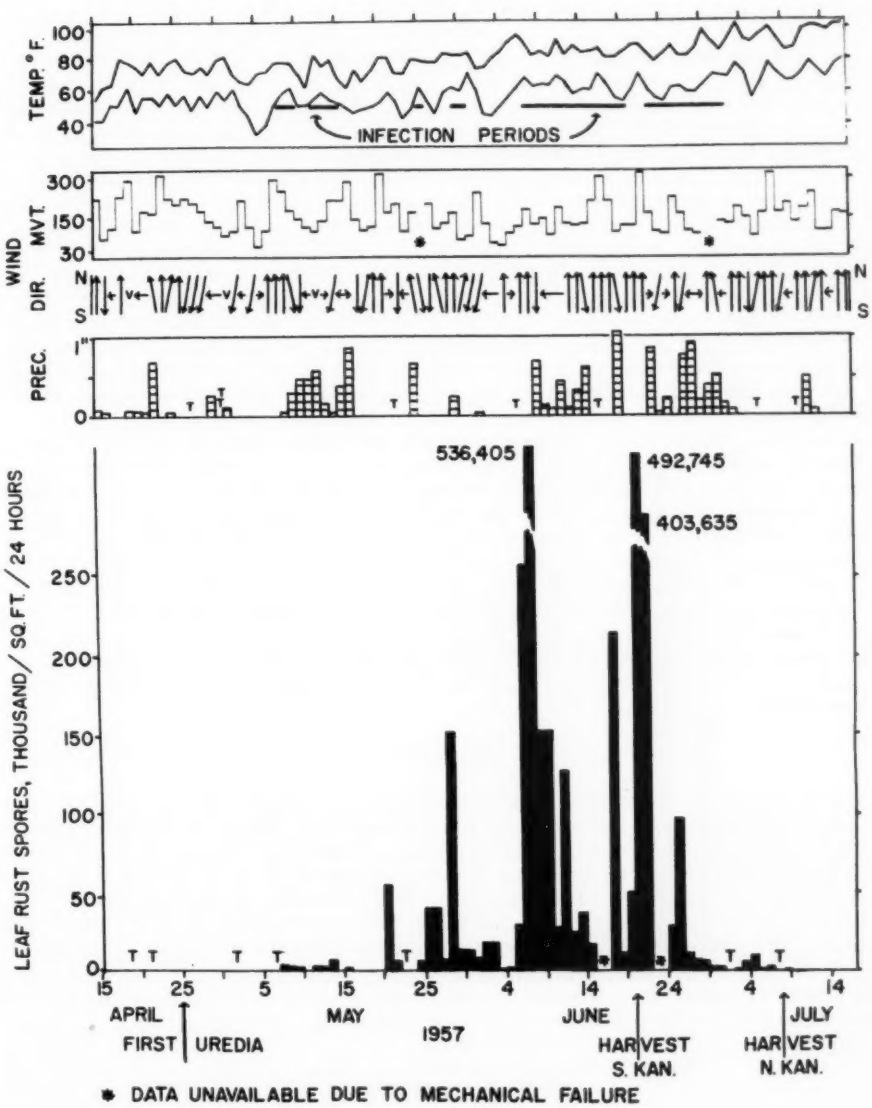

FIGURE 1. Numbers of leaf rust spores trapped per square foot per day on adhesive-coated slides exposed on roof of Willard Hall, Kansas State College campus, Manhattan, Kansas. Meteorological data from campus station. Wind movement indicates total number of miles of wind at sampling station.

in 1938, when the loss from leaf rust was estimated at 12 percent, was there a more destructive epidemic. Thus, the epiphytotic of 1957 stands as one of the most serious since records have been kept, a period of almost 40 years.

AIR-BORNE SPORES AND SPRING EPIDEMIOLOGY OF STEM RUST

The first stem rust uredospores were observed on the slides of April 10 as a trace (Fig. 2); however, for the next 6 weeks they were very scarce, occurring as traces only on May 3, 9, 14. The first spore shower at Manhattan was on May 28-30. The first pustules of stem rust were found June 1 in Wabaunsee County, northeastern Kansas, obviously arising from uredospores blown in before May 28. The long, cool spring delayed development of stem rust during May and early June. A heavy spore shower occurred June 7 and was followed by favorable temperatures and almost daily rains. As a result, stem rust began to increase. A rust survey on June 10-13 revealed the presence of stem rust as traces in all fields visited in eastern, southeastern, and south central counties of the State. Favorable infection conditions prevailed in the State from June 7 to 17 and as a result stem rust increased sharply in central Kansas. These infection periods are indicated in Figure 2. From June 17 on stem rust increased steadily with favorable infection periods on June 22, 26, and from June 29 to July 4, developing into a moderate epiphytotic in the northern half of the State, especially in fields of late-maturing wheat in the central counties.

As in previous years, stem rust developed late and spore showers became increasingly abundant as the wheat neared maturity. Fairly high numbers of uredospores were present in the air from June 11 to July 10 (Fig. 2), reaching a maximum on June 21. At this time wheat in southern Kansas was being combined, but there were still some green fields in central and north central counties. Frequent rains from June 8 to July 2, plus favorable temperatures and spore showers, resulted in several infection periods during this time. Stem rust developed rapidly in central and north central Kansas, particularly in late fields. By July 15 harvest had been completed in the northern counties, except in low spots and occasional fields, but not before there was considerable damage in fields of late-maturing plants. As a result of this late development, there was considerable stem rust loss in some areas, particularly in north central counties. For the State as a whole, the loss is estimated to be 3 percent, which is the highest since 1944.

OAT RUSTS

During the early part of May, prospects for a good oat crop in Kansas were the best in many years. Oats were tall, vigorous, and heavily tillered. However, heavy rains during late May and June caused extremely severe lodging. Crown rust was late in inception and increased slowly for a time. By mid-June it became very heavy in fields where the plants were not already flat on the ground with lodging. Stem rust of oats was late in development and did not become severe in most fields, although it was present in practically all fields by harvest time. Since individual crown rust uredospores cannot be distinguished from those of leaf rust of wheat, some of the spores recorded as leaf rust of wheat in Figure 1 are undoubtedly those of crown rust. Abundant inoculum and favorable conditions resulted in heavy crown rust infection. A loss of 5 percent was estimated for the State.

COMPARISON OF THE RUST SITUATION IN 1957 WITH PREVIOUS YEARS

Because 1957 was such a favorable rust year, it seemed desirable to summarize the rust picture as it has been observed over the past 25 years by the junior author. Table 2 reports the estimated losses caused by the two wheat rusts for the period 1932 to 1957, together with the date of first recorded appearance of each in the field each year. From this table it is evident that loss due to leaf rust in 1957 was exceeded only once, in 1938, and equalled only in 1949; however, 1935 and 1945 were also heavy leaf rust years. Six of the last 25 years have been years of heavy leaf rust damage.

It should be further emphasized that leaf rust does not normally overwinter in abundance in Kansas; 1945 and 1946 are the only exceptions noted. Leaf rust usually appears toward the end of April or the first of May. In some years, as in 1956, the first pustules were found about a month later than average. The time when the first field infections occur depends principally upon the supply of inoculum in Oklahoma and Texas during April and May, and upon

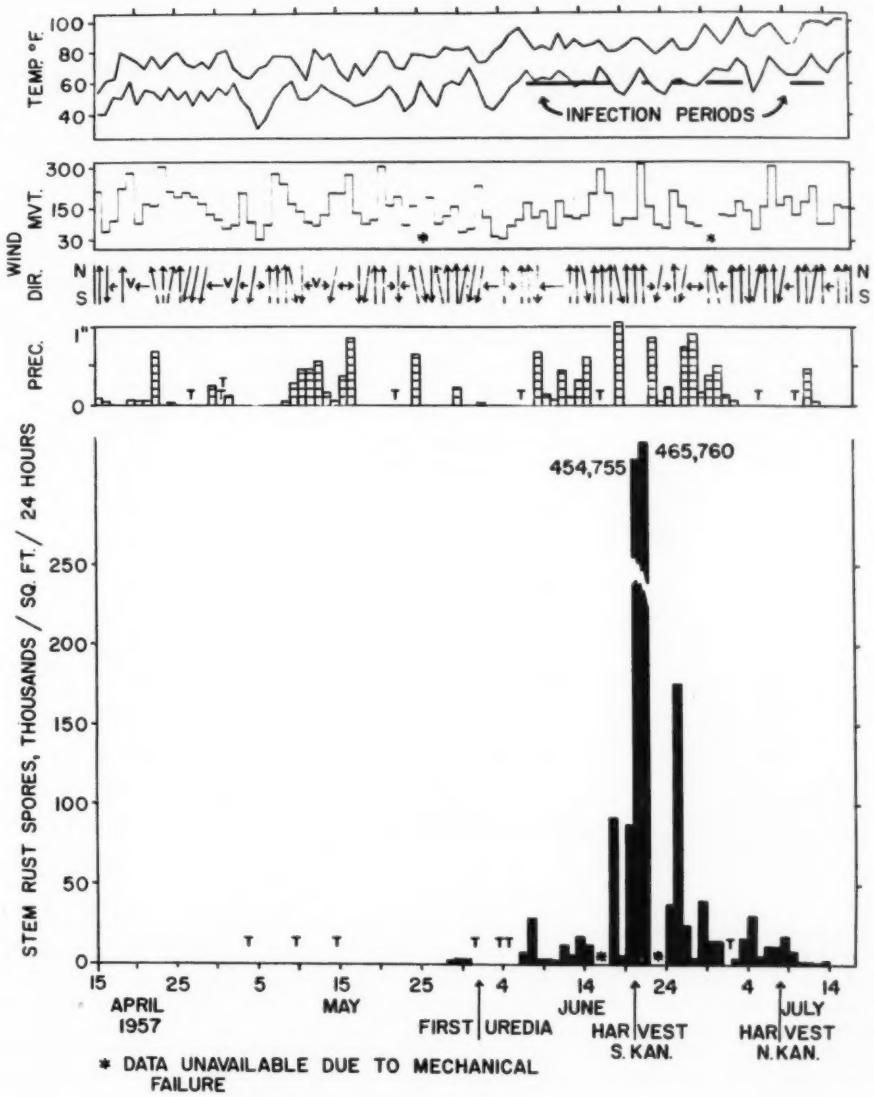

FIGURE 2. Numbers of stem rust spores trapped per square foot per day on adhesive-coated slides exposed on roof of Willard Hall, Kansas State College campus, Manhattan, Kansas. Meteorological data from campus station. Wind movement indicates total number of miles of wind at sampling station.

Table 2. Wheat rust losses and date of first rust in the field in Kansas, 1932-1957.

Year	Leaf rust		Stem rust	
	Percent loss	Date first recorded	Percent loss	Date first recorded
1932	1.5	Mar. 20[a]	0.5	late
1933	T	May 22[a]	T	June 20[a]
1934	T	Mar. 24[a]	T	---
1935	5	May 23[a]	12	June 5[a]
1936	0.2	May 21[a]	0.5	May 25
1937	0.4	May 13[a]	6.6	June 4
1938	12	Apr. 13[a]	3	May 1
1939	1.5	Mar. 31, Apr. 27[a]	0.2	late
1940	T	Apr. 1[a]	7	May 31
1941	5	Apr. 17[a]	T	May 19[a]
1942	1	May 4	0	June 5[a]
1943	0.5	Apr. 4[a]	T	June 1[a]
1944	0.5	May 17	4	May 30
1945	8	Overwintered (Mar. 27)	T	May 28[a]
1946	2	Overwintered (Mar. 21)	0	June 10[a]
1947	T	Apr. 28[a]	T	June 19[a]
1948	0	May 15[a]	T	May 26[a]
1949	10	Apr. 25	T	May 23[a]
1950	T	May 11[a]	T	June 14[a]
1951	2.0	May 28	T	June 18
1952	1.0	May 3	T	May 27
1953	0	June 1	1.5	June 3
1954	2.0	May 5	2.5	May 5
1955	2.5	Apr. 23	1.0	May 26
1956	T	June 1	T	May 23
1957	10	Apr. 25	3	June 1
Average	2.7		1.8	

[a]At Manhattan.

the occurrence of favorable infection periods in Kansas.

From Table 2 it will be noted that stem rust during the past 25 years has not caused as high losses as has leaf rust, the 12 percent loss in 1935 being the highest for the period. In addition, there have been comparatively few heavy stem rust years. Another point of interest is that stem rust seldom is found in the field until the end of May or the beginning of June. It is usually almost a month behind leaf rust. Only in 1938 did stem rust appear early in May, and in that year leaf rust also was unusually early. In only one case, 1956, did stem rust occur earlier than leaf rust, but in that year leaf rust was unusually late.

Records show that despite the lack of overwintering, wheat rusts occur year after year in Kansas. Since records were started there has never been a year when there was not some rust in the State. Only in 1948 and 1953 was no leaf rust recorded on the commercial crop, whereas stem rust was not recorded for either 1942 or 1946. Even in these 4 years it is very probable that there were traces of both rusts somewhere in the State.

Although stem rust is considered to be more damaging than leaf rust, the latter causes greater overall losses because it is found in abundance nearly every year, while stem rust is severe only in certain years. Over the last 25 years the average annual loss from leaf rust was 2.7 percent, and that from stem rust 1.8 percent.

The heavy losses attributable to wheat rusts are probably tied up with the agronomic characteristics of the wheat plant and the biology of the wheat rusts. In most years the Kansas winter wheat crop begins maturing just ahead of the heavy spore showers and thus escapes

heavy infection and often hot, dry weather in June effectively checks the development of both leaf and stem rusts. Leaf rust spores come in very early and in Kansas leaf rust appears in the fields around the first of May, providing a rather lengthy period for rust development. Fortunately, there are two factors which hold down leaf rust losses: the use of early maturing varieties, and the tendency of leaf rust to reduce yield rather than quality. When the growing season is long, inoculum abundant, and meteorological conditions favorable, as in 1957, leaf rust can cause heavy losses. Stem rust, on the other hand, comes in about a month later than leaf rust, the spore showers reach their maximum just as wheat nears maturity, and in most years wheat in Kansas escapes heavy damage. The shrivelled grain caused by stem rust makes this rust potentially more damaging than leaf rust, since it reduces both yield and quality. The plains of Kansas are an annual battleground for the struggle between the established and rapidly maturing winter wheat plant and the two air-borne attacking armies of leaf and stem rusts, with weather factors determining the outcome.

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GERMINATION TESTS AND FIELD STANDS OF CORN

T. E. Smith and J. P. Bailes

Hoppe's work[1] on the value of rolled-towel cold tests of seed corn was repeated using local soils and the genetically different corn hybrids of the Southeastern region of the country. The tests included 33 samples from remnant stocks of seven different hybrids grown in 1954, 1955 or 1956, processed and treated with Arasan plus DDT in commercial equipment and stored under ordinary warehouse conditions at Laurinburg, North Carolina.

Regular germination tests were conducted with the standard procedure. For the cold test a local soil high in organic content was used in the "dolls", otherwise the technique was the same as described by Hoppe[2]. Laboratory work was completed in January 1958. Field plantings to measure field stands were made April 16, 1958 on a location rather unfavorable for seed germination. Stand counts were taken 19 days later on four replications of 100 kernels each. A summary of the data follows:

Vitality class based on field stand (percent)	Samples (number)	Average germination: Field stand (percent)	Cold test (percent)	Standard procedure (percent)
51 - 60	1	55.0	34.0	83.0
61 - 70	1	70.0	69.0	98.0
71 - 80	6	77.8	77.7	97.2
81 - 90	18	86.8	85.9	97.5
91 - 100	7	91.9	90.6	99.3

The results show good agreement between field stands and cold tests with a correlation coefficient of 0.84, significant at the 1 percent level. The standard procedure gave no differentiation between samples of 70 percent or higher in field stand. In conclusion, the rolled-towel cold test was of distinct value in estimating the vitality of seed corn under local conditions.

EXPERIMENT FARM, McNAIR'S YIELD-TESTED SEED COMPANY, LAURINBURG, NORTH CAROLINA

[1]Hoppe, P. E. 1958. Correlation between laboratory cold test and field stands of corn. Plant Dis. Reptr. 42: 367-372.

[2]Hoppe, P. E. 1955. Cold testing seed corn by the rolled-towel method. Wisconsin Agr. Exp. Sta. Bull. 507, 5 pp.

STUDIES ON CRABGRASS SMUT, USTILAGO SYNTHERISMAE

Timothy A. Gaskin

Plants of large crabgrass, Digitaria sanguinalis (L.) Scop., were observed to be infected with a smut fungus, Ustilago syntherismae (Schw.) Peck, at several locations near Lafayette, Indiana. Since little is known about parasitism and life cycles of the smut fungi on non-economic plants, this report presents some of the results of a study of this fungus.

SYMPTOMS

The infected plants can easily be distinguished from healthy plants by the dwarfing induced by the parasite. In sporulating, the fungus prevents the formation of a normal inflorescence, reducing it to a few strands that are found within the sheath of the flag leaf (Fig. 1).

The dwarfing is characteristic and has been mentioned earlier (2). The internodes are shortened and the leaves are not as long as in healthy plants. The whole aspect of the plant is compressed, and the infected plants are more prostrate and spreading than the normal. Diseased plants also have a more purplish cast, appearing earlier in the fall, than healthy plants at the same location.

As the diseased plants head, the peduncle is greatly shortened and the inflorescence, instead of being borne above the plant, remains within the sheath of the uppermost leaf. Often there is another inflorescence, also smutted, found in the next lower leaf. The general aspect of a diseased plant is shown in Fig. 1.

PATHOLOGICAL HISTOLOGY

In order to determine which tissues or organs were invaded by the fungus, infected plants were cleared in chloral hydrate and stained with hot lactophenol-cotton blue to demonstrate the presence of the fungus. The fungus was found in two areas, the region of the inflorescence, where the fungus was sporulating, and at each node. All of the nodes were found to be invaded in infected plants. The internodes, leaves, and roots were not invaded by the fungus. The arrows in Fig. 1 indicate the presence of the fungus. The parenchyma cells directly above and below the internodal cavities were invaded but the fungus did not extend into the vascular tissues.

Infected nodes were planted individually and samples were examined at intervals to determine how the fungus invades the organs as they are formed, especially the inflorescence. As the new nodes were formed they were found to be invaded by the fungus from the subjacent node. The growing point itself was not invaded, but the undifferentiated parenchyma cells directly beneath the growing point were invaded.

The most interesting point was that the inflorescence was formed from the undifferentiated vegetative growing point before it was invaded by the fungus (Fig. 2). Note the smut fungus in the axis of the flowering spike. In later stages the entire inflorescence, except the rachises, was destroyed and replaced by the fungus. After the spores fall from the plant, the rachises remain as threads between the leaf sheaths.

A similar development of the inflorescence to a stage where it is clearly differentiated before the invasion of the fungus was reported by Vanderwalle (3) and has been observed by the author in the case of wheat invaded by Ustilago tritici (Pers.) Rostr. It remains to be determined whether the differentiation of the inflorescence induces the invasion of these previously uninvaded tissues. Also known is the effect the differentiated flower parts have on the sporulation of the fungus.

SPORE GERMINATION AND INOCULATION

Attempts were made to germinate the spores that were collected 1 week after the fungus began sporulating, after 6 and 12 weeks of storage at 2° C, and after 6 months of weathering in the field. The spores were seeded on acidified and non-acidified water agar, potato dextrose agar, and nutrient dextrose agar (Difco). No germination was obtained. This would suggest that the fungus has a long rest period and would also indicate that the fungus will not infect the host in the same year that sporulation occurs; thus the generation time is at least 1 year.

FIGURE 1. Crabgrass invaded with Ustilago syntherismae. Arrows show invaded tissues.

FIGURE 2. Young inflorescence of crabgrass being invaded by smut fungus (arrows).

In all cases where spores were plated out on a non-acidified substrate, a dirty-white viscous bacterium would develop around the masses of spores. This bacterium apparently was present in the spore masses of this fungus, but whether it was a parasite or a saprophyte was not determined.

Seeds and shoots were inoculated under vacuum with a spore suspension following the method presented by Fischer and Holton (1). None of the inflorescences were smutted, most likely owing to the non-germination of the spores described above.

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2. NORTON, C. 1896. A study of the Kansas Ustilaginaceae especially with regard to their germination. Trans. Acad. Sci. St. Louis 7: 229-241.
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STUDIES ON THE CONTROL OF LOOSE SMUT OF WHEAT[1]

D. E. Weibel[2]

Summary

Soaking seed in water for 4 1/2 days at 70° to 75° F reduced the incidence of loose smut in Quanah wheat from 17.2 percent in untreated seed to 0.6 percent in 1956 and from 4.6 down to 0.2 percent in 1957. Germination was reduced. In other treatments the addition of Ceresan to the soaks at the manufacturers' recommended rate for seed treatment, or of sodium hypochlorite at a concentration of 100 ppm of chlorine resulted in about equal smut control but improved the germination.

A presoak of 6 hours in water followed by storage in an airtight container for 4 1/2 days at 70° to 75° F also reduced smut from 17.2 percent down to 1.1 percent in 1956 and from 4.6 percent down to 0 percent in 1957, with little impairment in germination.

Antibiotic and fungicidal seed soaks, dust seed treatments, and foliar sprays were not effective in smut control, but additional tests are being conducted.

INTRODUCTION

Loose smut, Ustilago tritici (Pers.) Rostr., is a fungus disease that frequently damages wheat to some extent and occasionally causes heavy losses. Yield tests show that the loss is roughly proportional to the percentage of infected heads. Until recently the hot-water treatment has been the only means of controlling this disease. However, long soaks in water at room temperature have been used for controlling loose smut of barley, and the present studies were undertaken with the hope of extending these new techniques to loose smut of wheat. In addition, selected antibiotics and fungicidal agents used as seed soaks, dust seed treatments, and foliar sprays, were tested for the control of smut.

REVIEW OF LITERATURE

While testing selected chemicals and physical treatments for smut control, Tyner (3) discovered that loose smut of barley was 99.8 percent eliminated by presoaking seed for 6 hours in water and then immersing it in a 0.2% suspension of Spergon for 40 hours at 72° to 75° F. Two other agents, potassium iodide and oxyquinoline sulfate, showed some promise for loose-smut control in barley. Later Tyner (4) reported that loose smut of barley could be controlled as effectively by simply soaking the seed in water at room temperature for 56 to 64 hours. He also controlled loose smut in Stewart durum spring wheat by soaking it in water for 48 hours at room temperature. Leben and Arny (2) confirmed Tyner's results with barley, using both the water and Spergon soaks. Hebert (1) effectively controlled loose smut of barley by holding wet seed in airtight containers for 42 hours at 24° C after a presoak of 2 to 6 hours in water. He suggested that grain soaked for this short time was easier to dry than grain soaked for long periods. Weibel and Atkins (6) recommended the long-soak method for controlling loose smut of wheat based on the results presented in detail in this paper. Recently Tyner (5) proposed that the agent responsible for smut control in the germinal tissue of barley and wheat seed might be a quinone compound.

[1] Appreciation is extended to the Upjohn Company for providing oxime of cycloheximide U-7413, acetate of cycloheximide U-7414, semicarbazone of cycloheximide U-7415, Acti-dione, U-7567, and Filipin; to Chas. Pfizer & Company for Agri-mycin; to E. I. DuPont de Nemours & Company for thiram, ferbam, ziram, maneb, zineb, nabam, and calcium sulfamate; and to U. S. Rubber Company for Spergon and Phygon. A report of cooperative research between the Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Texas Agricultural Experiment Station.

[2] Research Agronomist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Texas Substation No. 6, Denton, Texas.

MATERIALS AND METHODS

Seed of Quanah wheat, known to be infected with loose smut, was used in all experiments. The incidence of smut in the seed used for the 1955 and 1956 tests was higher than that in seed used in 1957. Small amounts of seed were enclosed in cheesecloth bags and submerged in glass containers for treatment. Closed containers were used for the antibiotic and fungicidal soaks. The solutions were not changed during the tests. After soaking, the seed was spread out in a warm greenhouse to dry, but no attempt was made to maintain uniform temperatures. When the seed was dry it was collected and stored until sowing.

In the soaking experiment in 1955 water and solutions of Spergon and Ceresan were employed as smut-control treatments for periods of 36 to 72 hours. In 1956 these soaking periods were extended and additional treatments involving a presoak were used. In the presoak treatments the water was drained off after the intervals indicated, the surface moisture was blotted off, and the seed was placed in airtight containers. Each container was at least half full of grain. After the allotted time, the seed was spread out to dry in the greenhouse. The treatment periods were again extended in 1957.

Sodium hypochlorite (Purex) was used to make up solutions giving chlorine concentrations of 1, 10, 100, and 1000 ppm. Immersions for 6, 12, 24, 48, or 96 hours in these solutions and in water provided the treatments used.

Antibiotic soaks at 1, 10, and 100 ppm of oxime of cycloheximide, acetate of cycloheximide, semicarbazone of cycloheximide, Acti-dione, Agri-mycin, and Filipin were used for 2, 4, or 6 hours with sound Concho wheat seed in preliminary treatments in order to determine their effect on germination. All of these treatments were repeated on infected Quanah wheat seed.

Fungicidal soaks for 6, 12, 24, or 48 hours of thiram, ferbam, ziram, maneb, zineb, nabam, calcium sulfamate, and Phygon at 100, 1000, and 10,000 ppm were conducted with sound Concho wheat seed. Only part of these treatments were repeated on infected Quanah wheat seed.

Further exploratory tests were conducted using selected antibiotics and fungicides as dust seed treatments. The concentrations were calculated on the basis of weight. Not all of the dust would adhere to the seed, but the rows were sown by hand so that all the material was on or near the seed.

An additional experiment involved the application of foliar sprays of 10 antibiotics and fungicides at 10 and 100 ppm. Oxime, acetate, and semicarbazone of cycloheximide, Actidione, Agri-mycin, Filipin, nabam, zineb, calcium sulfamate, and Phygon solutions were applied with a knapsack sprayer on two dates to single rows of Quanah wheat separated by rows of uninfected wheat. The first spray was applied March 15, 1957, as spring growth was initiating, and the second was applied 11 days later while the plants were still small but in a very active state of growth.

RESULTS AND DISCUSSION

The incidence of smut and germination percentage resulting from soak treatments with water, Spergon, Ceresan, and water presoaks in 1955, 1956, and 1957 are presented in Table 1. All the treatments used in 1955 substantially reduced the incidence of smut, as compared with the check, but none was sufficiently effective to be practical. The Spergon suspension sharply reduced germination after 36 hours and reduced it to zero in soaks of 48, 60, and 72 hours duration. In 1956 and 1957 additional treatments with Spergon were not effective, but extended periods of soaking in water and Ceresan and the water presoaks, followed by holding the seed in airtight containers, proved effective. Soaking in water for 4 1/2 days reduced the incidence of smut in Quanah wheat from 17.2 percent in the check down to 0.6 percent in 1956, and from 4.6 percent in the check down to 0.2 percent in 1957. The germination of the seed was low initially and it was further reduced by this treatment. In other treatments the addition of Ceresan to the soaks at the manufacturers' recommended rate for seed treatment resulted in about equal smut control, and improved germination, with less fermentation and offensive odor.

Presoaking in water for 4 and 6 hours, followed by storage in an airtight container for 4 1/2 days, reduced the incidence of smut from 17.2 percent in the check to 1.8 and 1.1 percent, respectively, in 1956, and from 4.6 to 0 percent in 1957. In addition, the germination of seed treated in this manner was further improved, being at least equal to the check in 1956 but somewhat reduced in 1957.

Table 1. Incidence of smut, and seed germination, following soak treatments for the control of loose smut of wheat, 1955 to 1957. All tests conducted at 70° to 75° F.

Treatment	Time	Years of experiments					
		1955[a]		1956[b]		1957[c]	
		Infected heads/row	Germination	Infected plants/row	Germination	Infected heads/row	Germination
	(hours)	(number)	(percent)	(percent)	(percent)	(percent)	(percent)
Dry check		40.2	57	17.2	57	4.6	69
Water 120° for 95 min.		.3	40	0	39		
Water	36	29.5	51				
	48	26.3	49				
	60	25.7	43				
	72	22.5	45	6.0	53		
	84			5.5	55		
	96			2.1	38	0	33
	108			0.6	41	.2	23
	120					.3	17
Spergon, 0.2 percent	36	12.1	28	7.2	38		
	38			6.6	43		
	40			8.3	45		
	42			7.6	42		
	48		0				
Ceresan[d]	36	24.6	51				
	48	19.8	49				
	60	16.6	50				
	72	18.1	46	7.0	64		
	84			6.0	47		
	96			0.8	61	0	41
	108			0.9	50	0	39
	120					0	21
Water presoak, 6 hours[e]	72			10.8	63		
	84			10.1	56		
	96			8.4[f]	56	0	42
	108			1.1	69	0	45
	120					0	47
	132					0	53
Water presoak, 4 hours[e]	72			14.4	68		
	84			12.2	62		
	96			3.2	63		
	108			1.8	60		
	120			0.7	52		
Water presoak, 2 hours[e]	72			9.2	47		
	84			9.7	58		
	96			4.2	63		
	108			4.1	45		
	120			4.0	52		

[a] Average of 12 rows and 5 germination tests.
[b] Average of 4 rows, 1 germination test.
[c] Average of 3 rows and 2 germination tests.
[d] Ceresan at recommended rate.
[e] Indicated presoak in water followed by enclosure in airtight container after draining.
[f] Container accidentally opened for several hours during fourth 24-hour period.

Table 2. Incidence of smut, and seed germination, following sodium hypochlorite soaks for the control of loose smut of wheat, 1957. Test conducted at 70° to 75° F.

Time (hours)	Ppm chlorine from NaOCL (Purex) in soaking solution: 1		10		100		1000		0	
	Infection[a] (Percent)	Germination[b] (Percent)	Infection[a] (Percent)	Germination[b] (Percent)	Infection[a] (Percent)	Germination[b] (Percent)	Infection[a] (Percent)	Germination[b] (Percent)	Infection[a] (Percent)	Germination[b] (Percent)
6	3.2	67	3.7	59	4.1	62	1.6	56	4.6	73
12	5.0	69	3.0	60	3.9	70	1.7	58	3.8	67
24	3.4	64	5.5	66	2.3	71	3.8	57	3.6	52
48	.8	54	.2	64	1.5	62	.6	37	1.9	57
96	0	40	.7	42	0	56	1.4	37	.2	45
Dry check									4.4	48

[a] Average percent infected heads in three 5-foot rows.
[b] Average of 2 tests.

Table 3. Incidence of smut, and seed germination, following antibiotic soaks for the control of loose smut of wheat, 1957. Test conducted at about 70° F.

Antibiotic	Time (hours)	Ppm in soaking solution: 1		10		100	
		Infection[a] (Percent)	Germination[b] (Percent)	Infection[a] (Percent)	Germination[b] (Percent)	Infection[a] (Percent)	Germination[b] (Percent)
Oxime of cycloheximide	2	2.4	66	4.0	69	4.0	52
	4	3.5	69	3.5	71	3.7	61
	6	1.9	65	2.5	70	3.3	52
Acetate of cycloheximide	2	3.2	52	5.2	61	4.8	37
	4	2.4	74	2.3	52	2.8	6
	6	5.6	62	1.9	49	0	13
Semicarbazone of cycloheximide	2	4.4	70	1.5	64	3.5	26
	4	3.6	65	4.7	54	6.2	35
	6	2.8	69	7.3	66	2.4	17
Acti-dione	2	5.0	61	2.8	51	.9	20
	4	2.9	69	.9	54	.9	10
	6	3.6	50	5.9	46	2.0	10
Agri-mycin	2	3.5	69	1.9	72	2.4	71
	4	2.4	69	3.2	66	3.9	67
	6	1.1	75	4.6	64	5.7	64
Filipin	2	2.9	59	1.1	71	2.7	61
	4	3.9	65	.8	52	4.0	68
	6	3.9	66	3.6	69	4.4	68
Water (distilled)	2	4.0	62				
	4	2.2	56				
	6	3.1	76				
Dry check		5.3	74				

[a] Average percent infected heads in three 5-foot rows. [b] Average of 2 tests.

Table 4. Incidence of smut, and seed germination, following fungicidal soaks for the control of loose smut of wheat, 1957. Test conducted at about 60° F.

Fungicide	Time (hours)	Ppm in soaking solution: 100 Infection[a] (Percent)	100 Germination[b] (Percent)	1000 Infection[a] (Percent)	1000 Germination[b] (Percent)	10000 Infection[a] (Percent)	10000 Germination[b] (Percent)
Thiram	24			4.1	62	2.8	70
	48			2.7	62	4.6	67
Ferbam	24			4.2	67	2.5	62
	48			5.4	71	2.1	69
Ziram	24			2.1	71	6.6	64
	48			3.1	63	3.5	66
Maneb	24			3.3	76	4.3	64
	48			4.5	73	7.5	69
Zineb	24			2.8	69	4.7	68
	48			4.3	69	4.1	69
Nabam	6	1.9	67	4.0	66	3.0	52
	12	1.7	78	2.4	72	3.6	68
	24	4.7	67	2.1	62	3.4	43
	48	1.8	67	3.2	65	1.8	44
Calcium sulfamate	6	5.8	63	4.7	70		
	12	1.1	63	2.1	70		
	24	4.1	74	4.4	65		
	48	1.1	74	3.6	72		
Phygon	24	4.5	67	8.1	64		
	48	6.2	63	4.0	64		
Water (distilled)	6	5.0	69				
	12	4.9	66				
	24	4.6	67				
	48	4.7	68				
Dry check		5.3	74				

[a] Average percent infected heads in three 5-foot rows.
[b] Average of 2 tests.

The antiseptic qualities of the common bleaching agent, sodium hypochlorite, were employed in preparing soak solutions varying in the concentration of chlorine. Data presented in Table 2 show that soaking for 96 hours at all concentrations from 0 to 1000 ppm controlled smut. However, a 100 ppm concentration of chlorine aided materially in reducing the bacterial growth and fermentation in the solution and in maintaining the natural odor of the grain. Germination appeared to be benefited by all these soaking treatments, except by 1000 ppm chlorine. After 48 and 96 hours of soaking at this concentration the seed was bleached almost white and germination was reduced. The use of sodium hypochlorite in presoak tests was suggested, and this has been used in subsequent farmer-scale experiments with bushel and half-bushel lots of seed followed by enclosure in heavy polyethylene bags.

Table 5. Incidence of smut, and seed germination, following dust seed treatments for the control of loose smut of wheat, 1957.

Treatment	Rate[a] (ppm)	Infection[b] (Percent)	Germination[c] (Percent)
Acetate of cycloheximide	100	6.9	13
Semicarbazone of cycloheximide	100	8.1	27
U-7567	100	4.3	39
Acti-dione	1000		0
Agri-mycin	1000		0
Thiram	10000	7.0	61
Ferbam	10000	8.7	73
Ziram	10000	9.9	85
Maneb	10000	8.3	79
Zineb	10000	12.8	87
Calcium sulfamate	1000	9.2	82
Phygon	1000	6.5	83
Filipin	1000	7.0	86
Check		8.2	84

[a] Calculated on basis of weight.
[b] Average percent infected heads in three 5-foot rows.
[c] Average of 2 tests.

Preliminary antibiotic soaks of sound Concho wheat were conducted at concentrations of 1, 10, and 100 ppm to determine the effect on germination. At 100 ppm the acetate of cycloheximide, and Acti-dione reduced germination from 91 percent for the check to 30 to 40 percent after soaking for 2 to 6 hours. Nevertheless, these same treatments were applied to infected Quanah wheat. The incidence of smut and germination percentage from the treatments are presented in Table 3. Of the three cycloheximide derivatives used, the acetate cycloheximide proved to be nearly as phytotoxic as cycloheximide (Acti-dione) alone, as measured by reduced germination. The acetate of cycloheximide appeared to reduce if not to control smut in soaks at 10 and 100 ppm for 6 hours. Germination was sharply reduced, especially at the 100 ppm concentration. Field plants from the 100 ppm treatments with the acetate derivative and cycloheximide itself at the 2-, 4-, and 6-hour periods of soaking were yellow and shorter than normal. Additional tests with these two chemicals appeared warranted. Agri-mycin at 1 ppm for 6 hours substantially reduced smut but this needs to be substantiated by further testing. Unexplained were the surprising results throughout the test whereby the incidence of smut increased rather than decreased with additional time in the soak for a particular treatment. Such was the case for semicarbazone of cycloheximide at 10 ppm, Acti-dione at 10 and 100 ppm, Agri-mycin at 10 and 100 ppm, and Filipin at 1, 10, and 100 ppm.

Fungicidal soaks of sound Concho wheat were first tested to determine their effect on germination. Soaks of 6, 12, 24 or 48 hours at 100, 1000, and 10000 ppm with eight fungicides showed that only nabam and calcium sulfamate at 10000 ppm reduced germination. Since it appeared unlikely that the shorter period of soaking would be effective in controlling loose smut, a number of these were omitted in the subsequent soaks of infected Quanah wheat. The incidence of smut and percentage germination from these treatments are presented in Table 4. Data indicated that nabam and calcium sulfamate at 100 ppm concentration reduced the incidence of smut more than other treatments and warranted further tests. These results suggest a possible systemic action of these two chemicals in the control of smut.

Results of the dust seed treatments for controlling loose smut in Table 5 showed that cycloheximide (Acti-dione) and its derivatives, U-7567, and Agri-mycin all sharply reduced or prevented germination. Smut was not controlled, however, unless the incidence following the use of U-7567 represents a significant reduction.

The incidence of smut following foliar sprays indicated lack of control by the chemicals used. In fact, most of the treatments showed more smut than the check rows. Phytotoxic effects on the young plants were evident when 100 ppm of acetate of cycloheximide and Actidione were applied on March 26. Yellowing of foliage and stunting of growth were observed.

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CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, AND TEXAS AGRICULTURAL EXPERIMENT STATION, DENTON, TEXAS

EFFECT OF VERNALIZATION ON THE INCIDENCE OF LOOSE SMUT OF BARLEY, USTILAGO NUDA

J. G. Moseman and David A. Reid[1]

Summary

Twenty days at a temperature of 33° to 34° F was required to vernalize germinating seed of the winter barley variety, Wong (C.I. 6728)[2]. Vernalizing Wong and Atlas (C.I. 4118) spring barley at 33° to 34° for as long as 35 days did not reduce the incidence of loose smut from seed artificially infected with either culture 269 of race 1 or culture 244 of race 2.

INTRODUCTION

Information is needed on the effect of temperature treatments on the incidence of various diseases, since many investigators are growing winter barley in growth rooms under artificial light at controlled temperatures. The effect of vernalization of germinating artificially-inoculated barley on the incidence of loose smut, Ustilago nuda (Jens.) Rostr., was studied. The vernalization treatment consisted of prolonged chilling of germinating seeds at 33° to 34° F.

REVIEW OF LITERATURE

It is not possible to determine which of the two loose smuts were used in studies prior to the discovery by Tapke (6, 7) that there were two loose smuts, namely, Ustilago nigra, Tapke, a seedling infecting smut, and U. nuda, the floral infecting smut. Most fungicides and seed treatments which effectively control U. nigra do not control U. nuda.

Information is limited concerning the effect of vernalization or low temperatures on the incidence of U. nuda. Lasser (3) reported that vernalization induced winter barley to head in the greenhouse, but reduced the incidence of loose smut in plants grown from artificially-inoculated seeds. Leukel (4) found that keeping germinating seed at 5, 10, 15, 20, 25, or 30° C before emergence did not affect the incidence of U. nuda in plants from artificially-inoculated seeds, but the amount of infection from U. nigra was reduced at temperatures of 5° and 30° C. Both Hanna (2) and Bever (1) report that vernalization did not affect the incidence of loose smut of wheat, U. tritici, in plants from artificially-inoculated seed.

MATERIAL AND METHODS

The two varieties of barley, Wong (C.I. 6728) and Atlas (C.I. 4118), used in this study, were both susceptible to loose smut. Wong was selected because it is one of the most important commercial winter barley varieties in the eastern United States, and also is very susceptible to loose smut. Atlas was reported by Tapke (9) to be highly susceptible to all collections of loose smut with which it was inoculated.

Two cultures of U. nuda, No. 269 of race 1 and No. 244 of race 2, were used to determine whether cultures may respond differently to vernalization. Preliminary data indicated that Wong may be more susceptible to culture 269 than to culture 244.

The florets were inoculated on the day of, the day before, or the day after pollination, using a hypodermic needle to which a small rubber bulb containing dry spores was attached, as described by Shands and Schaller(5). The inoculated seeds were vernalized by germinating them on moistened blotters in Petri plates for 36 to 48 hours at room temperature, or until the coleoptiles had emerged. Seeds were then refrigerated at 33° to 34° F in moist sand in 4 inch by 8 inch tin pans, 2 inches deep. Vernalization treatments were started in time for the seedlings to be transplanted about September 15. After vernalization, the pans were kept at room temperatures for 24 to 48 hours or until the coleoptiles were 1 to 2 inches in length. The seedlings were then transplanted at 1-inch spacings in rows 3 or 4 inches apart in a green-

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[2]C. I. refers to the accession number of the Cereal Crops Research Branch, Crops Research Division.

house bench, similar to the method described by Tapke (8). Supplementary mazda lights were used from midnight to 2 A. M. each night, beginning when the seedlings were in the 3- to 4-leaf stage. Data were recorded in percent of plants infected.

RESULTS

The effect of vernalization in the winter variety Wong, for various periods, on heading and incidence of loose smut is shown in Table 1. Vernalization for at least 20 days was required to induce complete heading of Wong. When vernalized for only 15 days, 19 percent of the plants failed to head, but when exposed for 20 days or more all plants headed. The percentage of plants infected with loose smut was 43, 34, 41, and 43 after vernalization for periods of 35, 30 25, and 20 days, respectively. The percentage of plants with loose smut after vernalization for 15 or 10 days, and with no cold treatment, was not consistent; however, many of the plants were not effectively vernalized and failed to head.

Table 1. Effect of vernalization at 33° to 34° F for various periods, on heading and incidence of loose smut, U. nuda, in Wong winter barley.

Vernalization period (Days)	Total plants	Plants not headed (Percent)	Plants infected (Percent)
None	59	31	54
10	49	35	34
15	48	19	15
20	49	0	43
25	66	0	41
30	62	0	34
35	75	0	43

The spring variety, Atlas, was used to eliminate the effect of inadequate vernalization. The effect of vernalization on the incidence of loose smut in Atlas is shown in Table 2.

Table 2. Effect of vernalization at 33° to 34° F for various periods, on the incidence of loose smut, U. nuda, in Atlas spring barley.

Vernalization period (Days)	Total plants	Plants infected (Percent)
None	63	33
10	45	44
15	44	41
20	41	39
25	41	37
30	45	36
35	27	41
Total for all treatments	306	--
Average for all treatments	--	38

The percentage of smutted plants for the various treatments ranged from 33 to 44, with an average of 38 for all treatments, and there was no statistical significant difference between treatments.

Wong and Atlas were each inoculated with the two cultures, 269 of race 1 and 244 of race 2. With these two cultures, Wong had 38 and 39 percent smutted plants and Atlas 32 and 45 percent smutted plants. Since the difference in infection with the two cultures was not significant, the data from inoculations with the two cultures were combined in Tables 1 and 2.

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THE EFFECT OF BARLEY STRIPE MOSAIC ON THE PHOSPHORUS CONTENT OF EIGHT SPRING WHEAT VARIETIES[1]

T. J. Army, D. D. Dickey, and F. H. McNeal[2]

Summary

Seed of eight spring wheat varieties infected with barley stripe mosaic and healthy seed of the same varieties was planted under four levels of nitrogen fertilizer at Bozeman, Montana, in 1956.

Phosphorus content of plants approximately 6 inches tall was about 5 percent lower in diseased than in disease-free plants. There was no measurable difference in phosphorus content of diseased and disease-free plants of the eight varieties at maturity.

Nitrogen fertilization had no effect on the phosphorus content of the diseased and disease-free plants at the first sampling date, but tended to lower the phosphorus content of all plants at maturity.

The magnitude of the difference in phosphorus content between diseased and disease-free plants at the first sampling (6 inches tall) was not affected by nitrogen fertilization and was not related to varieties.

INTRODUCTION

Because of the existence of phosphorus in the nucleic acid portion of the nucleoprotein molecule, the primary component of viruses, the metabolism of this element in virus-infected plants has received considerable attention. However, most of the work has been directed toward determining the effects of phosphorus applications on symptom development, infectivity, and virus multiplication. Conflicting results have been reported regarding the phosphorus content and phosphorus fractions of infected versus non-infected plants. However, some of the discrepancies in results may be attributable to differences in degree and duration of infection and in the physiological age of the plant. Vayonis (4) studied the phosphorus metabolism of mosaic infected and healthy plants of tobacco (Nicotiana tabacum, var. Havana No. 38) in the greenhouse under a subirrigated hydroponic system. He reported no change in total phosphorus, expressed as a percentage of dry matter, between infected and healthy plants until 5 days after inoculation. At the time of visual symptom development the phosphorus content of the infected leaves tended to be about 10 percent less than that of the control leaves. However, Vayonis states that this 10 percent reduction might". . .well be attributed to the variation of experimental material."

In view of the inconclusive and conflicting nature of the previous results, it seemed desirable to examine the phosphorus status of field-grown wheat plants infected with barley stripe mosaic.

MATERIALS AND METHODS

Plants of Supreme, Lee, Pilot, Rescue, C. I. 13042, C. I. 13041, C. I. 12974, and Thatcher varieties of spring wheat were grown from diseased and disease-free seed at Bozeman, Montana, in 1956. The soil was classified as Bozeman light silty clay loam. Plots were 4 by 10 feet and contained 4 rows each. Paired diseased and disease-free plots of each variety were grown at random on each of four nitrogen levels randomly located in each of three replications. The planting was irrigated with approximately 4 inches of water on June 20 and again on July 12.

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Ammonium nitrate was applied on May 18, 10 days after seeding, by hand broadcasting. The fertilizer was applied at rates equivalent to 25, 50, and 100 pounds of nitrogen per acre.

No phosphorus was applied to any of the experimental plots. Previous experience with small grain crops on this site indicated that no yield response to phosphorus could be expected. Extraction of a composite soil sample from the experimental area with sodium bicarbonate (3) indicated that available phosphorus was not low. Chemical analyses showed 41 pounds of available P_2O_5 in the surface 6 inches, and 34 pounds at a depth of 6 to 12 inches.

Samples for chemical analyses were collected when the plants were about 6 inches tall (June 14, 15 inches of row) and again when the plants were mature (August 15, 24 inches of row). At each sampling, plants were cut off at ground level and dried at 75°C. Samples from each replicate of a given treatment were composited. The composited samples were ground in a Wiley mill (40 mesh) in preparation for chemical analyses.

Phosphorus was determined colorimetrically by the ammonium vanadate-molybdate method after dry ashing with $Mg(NO_3)_2$ at 570°C for 3 hours.

EXPERIMENTAL RESULTS AND DISCUSSION

Effects of nitrogen fertilization on symptom development, nitrogen content, and nitrogen uptake have been discussed by Army and McNeal (1). Interrelationships of nitrogen fertilization and agronomic characteristics of the eight varieties were discussed in a companion paper by McNeal et al. (2).

Mosaic infection caused moderate to severe reduction in plant height, total culms, dry matter production, kernel weight, test weight, and grain yield. Average yield reduction attributable to infection was 32.8 percent. Nitrogen content (percent of dry weight) of the diseased plants was higher than that of disease-free plants and was not affected by nitrogen fertilization. Total uptake of soil nitrogen and added nitrogen, however, was less for diseased than disease-free plants.

Phosphorus content of diseased plants of all varieties except C.I. 13041 was lower than that of the disease-free at the first sampling date (Table 1). As previously pointed out by McNeal et al. (2), C.I. 13041 was not affected materially by the disease. The average difference, significant at $P = .01$, in phosphorus content of diseased and disease-free plants was 0.02 percent, or approximately 5 percent of that of the disease-free plants. This is less than the 10 percent reduction reported by Vayonis from mosaic-infected tobacco. However, as pointed out by McNeal et al. (2), in no instance was there 100 percent infection in the wheat plants under study. It is entirely possible that the differences in phosphorus content between diseased and disease-free plants at the first sampling date would have been of greater magnitude if the percentage infection in the diseased plots had been greater.

There was no consistent or measurable difference in phosphorus content between diseased and disease-free plants in the sampling made at harvest. Average phosphorus content of all varieties at this sampling period was 0.289 percent.

Nitrogen fertilization had no measurable effect on phosphorus content of the diseased and disease-free plants at the first sampling date but tended to lower the phosphorus content of all plants at the final harvest. Varieties differed in phosphorus content at both sampling dates.

The magnitude of the difference in phosphorus content between diseased and disease-free plants at the first sampling date was not affected by nitrogen fertilization and was not related to varieties.

There is a possibility that the translocation of phosphorus from the roots to aboveground plant parts may have been impaired by infection with the mosaic. However, the data suggest that infection reduced the ability of the wheat seedlings to absorb phosphorus. This is especially so in view of the fact that nitrogen content of these same seedlings was higher in the diseased than in the disease-free plants.

These contrasting results between phosphorus and nitrogen may be explained on the basis of root growth and ionic mobility within the soil. It is psosible that mosaic infection reduced root growth in addition to top growth. Impaired root development would restrict the uptake of a non-mobile element like phosphorus. Nitrogen absorption might not be restricted because of the high mobility of water-soluble nitrate in the soil.

The data indicate that further work is needed to determine fully the interrelationships of infected spring wheat varieties and phosphorus fertility level. Roots should be harvested and analyzed, in addition to aboveground plant parts. This would aid in segregating the effects of infection on translocation of nutrients within the plant from absorption of nutrients by the plant roots.

Table 1. Phosphorus content (percent of dry matter) of aboveground plant parts of diseased and disease-free wheat plants. Mean values of four nitrogen levels.

Wheat variety	Percent phosphorus			
	First sampling		Harvest	
	Diseased	Disease-free	Diseased	Disease-free
Supreme	.393	.413	.286	.281
Lee	.383	.393	.310	.313
Pilot	.367	.401	.282	.288
Rescue	.387	.426	.272	.268
C.I. 13042	.399	.438	.323	.307
C.I. 13041	.440	.434	.298	.285
C.I. 12974	.379	.395	.274	.265
Thatcher	.408	.410	.294	.282
Mean	.394	.414	.292	.286

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HOJA BLANCA OF RICE AND THE HISTORY OF THE DISEASE IN COLOMBIA[1]

C. Garcés-Orejuela, Peter R. Jennings, and R. L. Skiles[2]

The discovery of hoja blanca of rice in Cuba, Venezuela, Panama, Costa Rica, and Florida (2) in the years of 1954-57 has caused considerable concern in all of the rice-growing regions of the Western Hemisphere. According to available information, hoja blanca was a new disease and very little was known about it except that it spread rapidly when it entered a new area, and, furthermore, severely reduced yields by causing stunting and panicle sterility. The transmission of a pathogenic agent by one or more species of leafhoppers, demonstrated in 1957 (8), indicated the probable virus nature of the disease. Various sources of resistance, mainly in the short grain "Japanese types", were found in the world rice collection of the United States Department of Agriculture in Cuba and Venezuela (2).

In December of 1957 it came to the attention of Colombian agronomists that symptoms very suspiciously like those of hoja blanca could be seen in experimental and commercial rice in the Cauca Valley of Colombia. This valley has been one of the country's principal rice-producing regions for many years. The experimental material comprised 2200 lines of the world rice collection obtained from the United States Department of Agriculture and planted at the Palmira Agricultural Experiment Station in the center of the Cauca Valley. All of these lines had been planted in Cuba and Venezuela and their reactions to hoja blanca were reported by Atkins and Adair (2).

In January of 1958 Dr. C. Roy Adair, of the United States Department of Agriculture, who had had occasion to study the disease in Cuba and Florida, toured the principal rice areas of the Cauca Valley and Tolima in company with the authors and other Colombian plant pathologists and rice breeders, and confirmed the existence of hoja blanca in Colombia. It was found widespread in both rice areas, and the syndrome was typical of the disease as it has been described previously (1, 7, 8).

A high degree of prevalence and severity of hoja blanca was found in the world collection at the Palmira Experiment Station. Disease ratings of nearly all individual lines corresponded to those recorded for the same material in Cuba and Venezuela (2). In the Cauca Valley several commercial fields of Bluebonnet 50, Zenith, and Early Prolific and some local varieties developed by selection from older commercial varieties showed varying degrees of severity. Diseased plants were found in all fields. In one relatively large planting hoja blanca was so widespread and severe that the owner planned to plow under the crop. In other fields, however, the disease was limited to a few scattered plants. Younger rice of 50 to 70 days consistently showed much more disease than rice that was nearing maturity. These observations indicated that date of planting, as has been noted in Cuba, may influence the amount of disease.

In Tolima, hoja blanca was readily found in Bluebonnet 50 and Rexoro, the principal varieties of the region. Again there was a wide range of prevalence and severity, with 20 to 30 percent of the plants showing symptoms in some fields. No hoja blanca was observed in two fields of Century Patna which was nearly ripe. Red rice was highly susceptible. As in the Cauca Valley, the incidence of the disease was found to be highest in late-seeded rice.

At the time of Dr. Adair's visit to Colombia the senior author called attention to the fact that he had seen and described what was evidently the same disease in Colombia as early as 1935. Even at that time he had referred to the disease as "chlorosis or hoja blanca." In 1940 and 1941 the senior author wrote (5, 6): "(Hoja blanca) is found in most of the rice zones of the country, causing losses of greater or lesser degree according to the intensity and the time when it occurs. The first references to this disease indicate that it first appeared in the Cauca Valley. . . in the year 1935-36. Since then it has appeared in Tolima, Huila, Magdalena ... and Santander Norte. The farmers differ considerably in their opinions of the importance of the disease." Bernal-Correa, who at one time was the plant pathologist at the Palmira Experiment Station, wrote in 1939 (3): "(Hoja blanca), according to the farmers, first appeared three years ago. It is found uniformly distributed (over the Cauca Valley), but its intensity is not as great as Helminthosporium." And in 1940, he stated (4): "The name hoja blanca that has been given to this disease is due to the color of the infected plants. A plantation affected by this disease can be distinguished at a distance by the typical color of the leaves which. . . have a lemon-yel-

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low hue. Some chlorotic plants recover and others die; some leaves ... show yellow, parallel stripes along the veins. (If mature plants) do not die, they do not produce seed. The chlorosis is usually not found in the entire plant but rather in some of the tillers. (It can be noted) that while some tillers of a single plant are entirely healthy, others are completely infected." In the same report, Bernal-Correa also noted the susceptibility of such varieties as Fortuna, Rexoro, Lady Wright, Early Prolific, Guayaquil, Santa Maria, and others. One variety, "Precoz 6", was highly resistant and yielded well.

According to observations of the senior author and Señor Gabriel Lopez, who worked at the Palmira Experiemnt Station as a rice breeder from 1942 to 1953, the prevalence and severity of hoja blanca has varied considerably from year to year in the Cauca Valley. In some years the disease was not observed, while in others it caused some concern to the rice farmers. It would be impossible to obtain even rough estimates of rice yield reductions in former years due to hoja blanca in the Cauca Valley or elsewhere in Colombia. The pathologists at the Palmira Experiment Station have changed several times in the intervening years since the senior author was stationed there, and the records have not been maintained continuously. Furthermore, any information obtained from the farmers themselves would be mostly hearsay.

From the information presented here it seems probable that hoja blanca of rice is not a new disease in the Western Hemisphere, as formerly believed, but rather one that has been known for at least 23 years in Colombia. It was severe enough in certain fields in Colombia in the early part of 1958 to destroy the crop completely. On a few occasions in former years it has caused sufficient damage in rice plantations to be quite noticeable, but no information was obtained with respect to loss estimates. In other years hoja blanca was not seen, an indication that the disease is similar to other plant diseases in general in regard to its cyclic development and is not one that causes tremendous losses every year.

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THE NATIONAL FACULTY OF AGRONOMY, MEDELLÍN, COLOMBIA, AND THE COLOMBIAN AGRICULTURAL PROGRAM OF THE ROCKEFELLER FOUNDATION

SOME CHARACTERISTICS OF EIGHT MOSAIC AND TWO ROSETTE VIRUSES OF CHRYSANTHEMUM

Philip Brierley and Floyd F. Smith[1]

Summary

Eight mosaic and two rosette viruses of chrysanthemum were distinguished on the basis of reactions by chrysanthemum varieties, petunia, and cineraria and of transmissibility by sap and the aphid Myzus persicae (Sulz.). All but two of the original source varieties carry the respective viruses without symptoms. The more virulent viruses are readily superimposed on the milder ones. Virus-free stock was reclaimed by heat treatment from six of ten virus source varieties. The value of chrysanthemum test varieties for detecting these and other viruses is discussed.

INTRODUCTION

Virus diseases of the mosaic type in chrysanthemum have been reported in several earlier papers. It seems likely that Welsh's (10) stunt mottle included a mosaic, as suggested by Keller (8), but this is unconfirmed. In 1951 Keller reported virus Q as distinct from chrysanthemum stunt virus, but he did not refer to virus Q as a mosaic virus. The virus B described in the Netherlands by Noordam (9) was inactivated at 70° to 80° C had rod-shaped particles, produced antigenic reaction, and induced characteristic local lesions in petunia. He did not refer to virus B as a mosaic virus. Brierley (2) showed that mosaic viruses naturally occurring in different chrysanthemum varieties produce different responses in the test varieties Good News and Friendly Rival. Ivory Seagull rosette was first reported (4) in 1951, as Ivory Seagull mosaic; this disease was briefly described as chrysanthemum rosette by Brierley (1) in 1954.

In the present paper eight mosaic and two rosette viruses are distinguished on the basis of transmissibility and test-plant responses. Reactions that the ten viruses cause in chrysanthemum test varieties and in cineraria and petunia are summarized in Table 1.

MATERIALS AND METHODS

Chrysanthemum test varieties used in this study were recommended by other workers or used by propagation specialists for detection of stunt or other chrysanthemum viruses. The variety Blanche was recommended by Keller (8) as an indicator of stunt virus. It is also one of the best indicators for aster yellows and chrysanthemum flower-distortion viruses (6). All known stocks of Blanche carry a mosaic and a rosette virus without symptoms; therefore, reisolations of mosaic and rosette viruses from this test variety are not feasible. Other test varieties are available in virus-free condition. Blazing Gold and the Mistletoe varieties (Bronze, Golden, Pink, and White) are used as indicators of stunt virus; Good News (Fig. 1E), the Mistletoe varieties, and Dynamo (Fig. 1F) as indicators of mosaic viruses. The variety September Morn introduced by Yoder Bros. in 1953 is not an indicator of these viruses, but was tested because of its notable virus tolerance.

Following Noordam's (9) report of petunia as a local-lesion host for his virus B, two varieties were used for chrysanthemum indexing. The variety Single Small-flowered Dwarf Velvety Blue (called Velvety Blue herein) developed local lesions when inoculated with four of the mosaic viruses, and developed systemic infections when inoculated with the mosaic viruses from Good News and Blanche. The variety Heavenly Blue developed local lesions more uniformly than the first-named variety, but it was not systemically invaded by any chrysanthemum mosaic virus.

Cineraria (Senecio cruentus DC.) "Cramer's Hybrids" is susceptible to some of the mosaic and to one of the rosette viruses, but does not express symptoms. Since this plant is an excellent virus source and a favored food plant for aphids, it was used in transmission tests by sap and by Myzus persicae (Sulz.).

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Table 1. Reactions[a] by six varieties of chrysanthemum, by cineraria and by petunia to eight mosaic and two rosette viruses of chrysanthemum..

Source Plants	Test Plants: Chrysanthemums: Blanche	Blazing: Gold	Dynamo	Good News	Golden Mistletoe	September Morn	Other: Cineraria	Other: Petunia
Reaction to mosaic virus from:								
Superlative	F	VDER	BVD	VCDN	VDN	O+	O+	L+
Good News	O	O-	BV	VCDN	VDN	O+	O+	L, S+
Yellow Doty	O	O-	O+	VCD	VDN	O+	O+	L+
Nightingale	O	O-	BV	V	VD	O+	O+	L+
Improved Bronze Daisy	O	O+	BVRN	I+	V	O+	O+	L+
September Morn	O	O-	BV	O-	O-	O+	O-	L-
John Cooper	O	O-	O-	EDIN	DRY	O+	O-	O-
"Hinckley"	O	V	BV	DIRY	VDRYN	O+	O+	O-
Reaction to rosette virus from:								
Ivory Seagull	O	VCDR	I	DIR	VDR	O+	O+	O-
Yellow Rayonante	F	VEDRN	VRD	VIDRY	VIDN	Y+	O-	O-

[a] Key to reactions:

B blotches
C crinkle
D distortion
E epinasty
F flecks
I interveinal mottle
L local lesions
N necrosis
R rosetting
S systemic symptoms
V veinbanding
Y yellowing
O symptomless
+ reisolated, - not reisolated

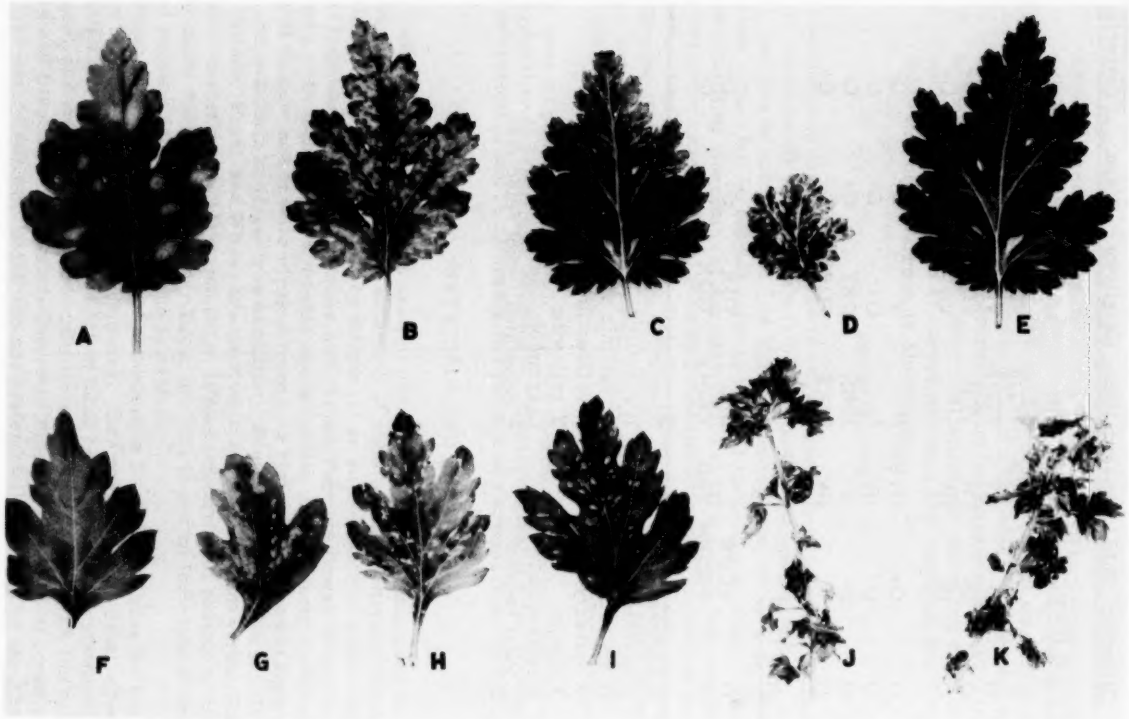

FIGURE 1. Leaf symptoms of chrysanthemum virus diseases. A - E) Variety Good News. A) Local lesions produced by Hinckley mosaic. B) Interveinal mottling caused by Improved Bronze Daisy mosaic. C) Veinbanding produced by Nightingale mosaic. D) Veinbanding, crinkle, and distortion caused by Good News mosaic, superimposed on Nightingale mosaic. E) Healthy. F - G) Variety Dynamo. F) Healthy. G) Yellow blotches produced by Rose Masterpiece mosaic (strain of Improved Bronze Daisy mosaic). H - I) Flecking in Blanche caused by Superlative complex. J - K) Leaf distortion and necrosis in Golden Mistletoe. J) Caused by Yellow Doty mosaic. K) Caused by Blanche mosaic.

Graft transmission was used extensively since chrysanthemums are readily grafted and all chrysanthemum viruses are so transmitted. Grafting established the best test varieties for each virus, and also the interval for symptom expression. Test varieties so determined were used in transmission tests by sap and by aphids. All tests of aphid transmission were made by the standard procedure for nonpersistent viruses: use of a period of starvation followed by short acquisition and infection feedings.

Reclaiming healthy tip cuttings from virus-diseased plants was attempted in a greenhouse compartment 8 X 8 X 7 feet at the eaves, and heated by a steam unit heater. An electric blower behind the heater and a fan in the opposite corner of the chamber helped to equalize temperatures. Supplementary lights, controlled by a time clock, kept the chrysanthemums in vegetative condition during the season of short days. A thermostat at about plant-top level maintained the temperature at 35° C day and night. Automatic ventilators opened when the temperatures exceeded 35°. These controls maintained the temperature at 35° at the thermostat, but excesses of 5° to 10° occurred on sunny days, especially during summer. Since considerable variation in temperature occurred within the chamber, the time-temperature combinations for heat inactivation cannot be considered closely reproducible. However, the fact that healthy material can be reclaimed from certain diseased plants is still of interest.

CHARACTERISTICS OF THE VIRUSES

Superlative Virus Complex

The source variety Superlative, supplied by C. J. Olson, Yoder Bros. Inc., Barberton, Ohio, in October, 1955, is of English origin, vigorous, and without symptoms. On graft-indexing the variety for stunt virus, Olson noted a distinctive flecking produced in Blanche, a response not previously recognized but subsequently produced by several renamed imports from England and by White and Yellow Rayonante, long grown in America.

Irregular chlorotic flecks (Fig. 1H, I) appeared in Blanche 4 to 6 weeks after grafting; these later turned brown and necrotic, and the leaf lamina became distorted. In Blazing Gold the leaves, especially the terminal lobes, curled downward after 6 weeks. The young shoots later formed rosettes (Fig. 2E); the leaves showed veinbanding or interveinal yellowing and then reddening and tattering. Flowers of infected Blazing Gold were slightly irregular and about 20 percent smaller than normal ones. Yellow blotches appeared in leaves of Dynamo after 2 to 3 months, and discontinuous veinbanding, with leaf distortion, was evident after 3 months.

After 2 months Good News developed veinbanding, deep crinkling, and distortion of leaves, followed by leaf necrosis. The virus was lethal after 4 months. After 6 weeks Golden Mistletoe developed veinbanding, leaf distortion, and necrosis. Black necrosis later appeared in shoot tips and in stems below scions; plants were killed in about 4 months. No symptoms were produced in September Morn, but the virus was recovered. The Superlative mosaic virus also caused a green blister mottling in Dauntless, yellow veinbanding in Friendly Rival, and a green and yellow interveinal mottling in Indianapolis White.

When sap was transferred from Superlative in May, 1956, Superlative virus complex failed to infect either 10 Blanche or 10 Dynamo plants. Transfer trials at that time with Myzus persicae also failed. In similar tests in June, 1957, the virus was transferred from Superlative to 5 of 10 Good News plants by leaf rubbing, and 7 of 10 by the fresh-leaf method. Both the mosaic and the rosette component were thus transmitted to Good News. Sap transmission from Superlative to cineraria and Heavenly Blue petunia produced no symptoms in the former, and only local lesions in the latter. Sap transfers from cineraria and petunia to Good News chrysanthemum caused infection in 5 of 5 and 3 of 3 plants, respectively. In each case, yellow-blotch local lesions appeared in Good News within 30 days, and systemic yellow veinbanding followed. No leaf distortion, crinkling, or necrosis appeared. This suggests that cineraria and petunia separated the Superlative virus complex, and that only a mild mosaic virus similar to Nightingale mosaic virus was recoverable from these test plants. This mosaic virus, unlike the parent Superlative virus complex, failed to produce fleck symptoms in Blanche. The other component, which has not been separated, is believed to be a rosette virus of the Yellow Rayonante type. Myzus persicae transfers from cineraria to Good News failed to transmit either component of the Superlative complex.

The Superlative virus complex was superimposed by graft on test chrysanthemums previously infected with the mosaic viruses from Good News, Yellow Doty, Nightingale, Improved Bronze Daisy, and September Morn. In each case the Superlative complex produced its char-

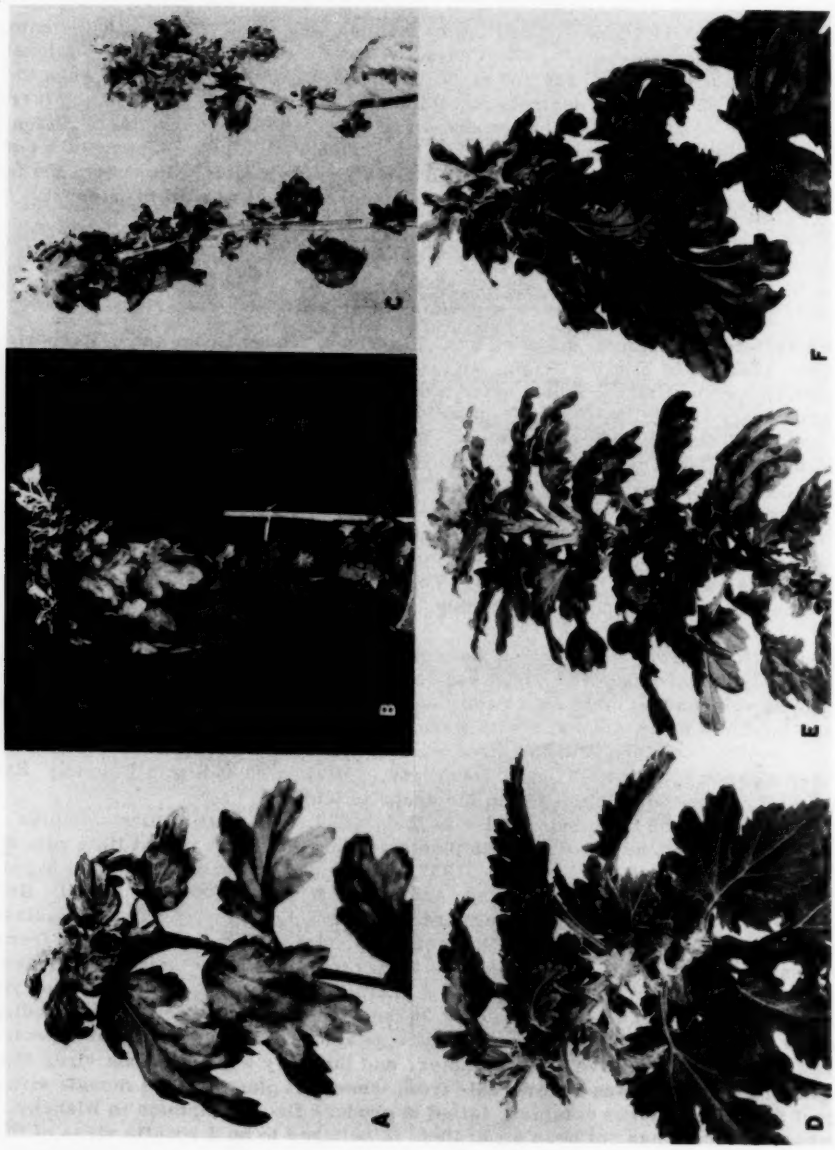

FIGURE 2. Plant symptoms of chrysanthemum virus diseases. A) Improved Bronze Daisy mosaic in Dynamo. B) Hinckley mosaic in Good News. C) John Cooper mosaic in Good News. D) Ivory seagull rosette in Good News. E) Superlative complex in Blazing Gold. F) Yellow Rayonante rosette in Blazing Gold.

acteristic symptoms, overriding the effects of the virus previously present.

No scions free of the Superlative virus complex were recovered from Superlative by heating stock plants 1 to 6 months at 35° C and testing scions on healthy Blazing Gold or Good News. Both the mosaic and rosette virus components of this complex are evidently tolerant of heat.

Good News Mosaic Virus

The variety Good News is occasionally found naturally infected with Good News mosaic virus, which causes characteristic veinbanding, deep crinkling and distortion of leaves (Fig. 1D), with occasional necrosis of buds and leaves. Infected plants were supplied by C. J. Olson, in March, 1951. The mosaic virus present in Blanche, together with a rosette virus, resembles Good News mosaic virus. The two viruses in Blanche are sap-transmissible to cineraria, in which both are symptomless. On return inoculation to healthy Good News, the mosaic and rosette viruses expressed symptoms in different test plants. Another collection, similar to Good News mosaic, was received from Florida, in December, 1955, in the variety Amber Bright.

On graft inoculation Good News mosaic virus produced no symptoms in test varieties Blanche and Blazing Gold. The virus was not recovered from Blazing Gold on backgrafting to Good News after 7 and 14 weeks' contact. In Dynamo the Good News mosaic virus produced yellow blotches and some veinbanding in leaves after 4 to 6 weeks. In Golden Mistletoe this virus produced yellow veinbanding with leaf distortion after about 5 weeks, and blasting of leaf buds and leaves followed. No symptoms were produced in September Morn, but the Good News mosaic virus was reisolated from it.

Sap transmission of Good News mosaic virus succeeded best during spring: e.g. 9 of 25 Good News to Good News in April, 13 of 15 in May, but 0 of 30 in late August. Myzus persicae also transmitted this virus, in low percentages, but only during the spring. Sap transmission to Velvety Blue petunia produced yellow local lesions after about 3 weeks, followed by systemic invasion in some plants, evident as blotches and wedges of the same color. The mosaic viruses from Good News and Blanche were the only chrysanthemum mosaic viruses to invade petunia systemically. In the variety Heavenly Blue, Good News mosaic virus produced local lesions only, but the virus was recovered unchanged on subinoculation from petunia to Good News. Local blotching appeared in 3 of 3 Good News plants in 30 days, and veinbanding and deep crinkling in 60 days. This virus infected cineraria without symptoms; it was recovered unchanged in 5 of 5 Good News, in which it caused yellow local lesions in 20 days and veinbanding and crinkling in 60 days. Myzus persicae transmitted this virus from cineraria to 1 of 5 Good News chrysanthemums, typical symptoms appearing after the usual interval.

Good News mosaic virus was superimposed by graft on test chrysanthemums previously infected with the mosaic viruses from Yellow Doty, Nightingale (Fig. 1D), Improved Bronze Daisy, and September Morn. The combination with Yellow Doty mosaic produced symptoms intermediate between those of the two viruses separately. Good News mosaic virus produced its typical symptoms in the three other combination infections, overriding the viruses previously present.

When mosaic-affected Good News plants were held at 35° C and tip scions were tested by grafting to healthy Good News, none were found healthy after 1, 2, or 3 months' exposure, but all were virus-free after 4, 5, and 6 months' heating. Symptoms disappeared from the stock plants in the hot room after 4 to 6 weeks. When these stock plants were returned to usual greenhouse conditions after 6 months' heating, mosaic symptoms reappeared in them gradually after 1 to 3 months. Blanche mosaic virus (Fig. 1K), which resembles Good News mosaic in other characteristics, is more tolerant of heat. When Blanche plants were held 6 months at 35° C, all tip scions tested still carried both a mosaic and a rosette virus.

Yellow Doty Mosaic Virus

Variety Yellow Doty, carrying a virus without symptoms, was supplied by C. J. Olson, in December, 1954, together with the varieties Tuxedo and Smith's Superlative, also symptomless and carrying the same virus or variants of it.

Yellow Doty mosaic virus produced no symptoms in graft-inoculated Blanche or Blazing Gold. It was not reisolated from the latter variety. In Good News this virus produced veinbanding and marginal crinkling in 30 days. Symptoms in this test variety were considerably

milder than were those of Good News mosaic virus. Yellow Doty mosaic virus invaded Dynamo without symptom production, and was recovered unchanged. In Golden Mistletoe this virus caused yellow veinbanding, leaf distortion, and blasting of leaf buds and leaves (Fig. 1J), essentially the same series of symptoms caused by Good News mosaic virus. Yellow Doty virus produced no symptoms in September Morn, but was reisolated from it.

This virus was not transmitted from Good News to Good News by mechanical inoculation or by Myzus persicae transfer in May, 1956; in June, 1957, one of 10 Good News plants was infected by the fresh-leaf method, but none of 10 by mechanical inoculation. This virus produced only local lesions in Velvety Blue and Heavenly Blue petunias. From the last-named petunia variety it was recovered in 3 of 3 Good News plants, which expressed blotch local lesions in 30 days, and later the typical symptoms of yellow veinbanding and marginal crinkling. This virus infected cineraria without symptoms and was recovered from cineraria in 5 of 5 Good News plants, which developed blotches in rubbed leaves after 20 days, and systemic veinbanding and crinkling after 60 days. Myzus persicae failed to transmit this virus from cineraria to Good News chrysanthemum.

Yellow Doty mosaic virus was superimposed by graft on test chrysanthemums previously infected with the mosaic viruses from Nightingale, Improved Bronze Daisy, and September Morn. In each case the Yellow Doty virus dominated and expressed its usual symptoms.

When mosaic-diseased Yellow Doty plants were held at 35° C and tip scions were tested on healthy Good News, none were found virus-free after 1 to 2 months, 1 of 2 was healthy after 3 months, and 3 of 3 after 4, 5, and 6 months.

Nightingale Mosaic Virus

The variety Nightingale, supplied by C. J. Olson in February, 1951, carried a mild mosaic virus, together with tomato aspermy virus, without symptoms. Nightingale was free from aspermy virus in Holmes' (7) tip-cultured stock and in plants that we freed of aspermy virus by heat treatment. The Nightingale virus appears to be common in the United States, for this or very similar viruses occur in many chrysanthemum varieties without symptoms.

Nightingale mosaic virus produced no symptoms in graft-inoculated Blanche or Blazing Gold. It was not reisolated from the latter variety. In Dynamo this virus produced yellow blotches after 6 weeks, with a mild yellow veinbanding. In Good News it caused yellow veinbanding in 4 to 6 weeks (Fig. 1C) without leaf distortion or crinkling. In Golden Mistletoe, veinbanding appeared in 4 to 6 weeks, followed by strong yellow-vein mosaic and some distortion of the leaves. September Morn can carry this virus without symptoms, and the virus is recovered unchanged.

Nightingale mosaic virus was transmitted from Good News to 5 of 10 Good News plants by leaf rubbing, and to 6 of 10 by the fresh-leaf method in April. It was readily transmitted in the nonpersistent manner by the aphids Macrosiphoniella sanborni (Gill.), Myzus persicae, Myzus solani (Kltb.), and Rhopalosiphum rufomaculatum (Wilson) (5). It was transmitted to petunia, producing yellow local lesions only in Velvety Blue and Heavenly Blue varieties. From the last-named it was recovered in 3 of 3 Good News plants, which expressed blotch local lesions after 30 days, and later the typical vein mosaic. It infected cineraria without symptoms, and was recovered in 5 of 5 Good News plants, which developed yellow local lesions in 20 days and the typical mild mosaic mottling after 60 days. Myzus persicae transmitted this virus from cineraria to only 1 of 5 Good News chrysanthemums. This is surprising, because cineraria is a favored food plant for this aphid, and M. persicae transmitted this virus readily from Good News to Good News (5).

Nightingale mosaic virus was superimposed by graft on test chrysanthemums previously infected with the mosaic viruses from Improved Bronze Daisy and September Morn, in each case dominanting the virus previously present.

Nightingale plants infected with mosaic and aspermy viruses were placed at 35° C, and tip cuttings were rooted after 11 weeks and after 6 months. Four of the 8 cuttings tested aspermy-free on tobacco after 11 weeks, and 16 of 19 after 6 months. Scions from the plants found free of aspermy virus were grafted to Good News to test for mosaic. All but 1 of 20 scions induced mosaic in Good News in 6 weeks or less. A single scion produced mosaic in this test variety after 5 months. Heating evidently reduced the virus titer in this scion to a low level, but failed to eliminate it. The Nightingale plant that furnished the scion of low virus titer was then returned to 35° C, and scions from it were tested on Good News after 2 to 12 months' further heating. One of 3 scions proved healthy after 2 months, 1 of 3 after 3 months, 0 of 3 after 4 months, 0 of 3 after 5 months, 3 of 3 after 6 to 12 months.

Improved Bronze Daisy Mosaic Virus

In November, 1954, C. J. Olson supplied the varieties Improved Bronze Daisy, California Early Mensa, and Bronze Masterpiece, with the notation that his graft-index tests were negative on Good News but positive on Dynamo. The virus in Improved Bronze Daisy was retained as the type. After preliminary screening, California Early Mensa was discarded as a duplicate source and Bronze Masterpiece as source of a slightly milder variant. All three varieties carried the virus without symptoms.

Improved Bronze Daisy mosaic virus produced no symptoms on graft-inoculated Blanche or Blazing Gold, but the virus was recovered from Blazing Gold. On graft inoculation to Dynamo this virus caused yellow blotching (Fig. 1G) and veinbanding in 4 to 6 weeks, with epinasty and rosetting (Fig. 2A) of terminal shoots after 2 months. After 3 months, regrowth with small leaves developed from the rosettes; brown corky areas and occasional black necrosis appeared on stems. Lateral buds developed into shoots with very short internodes and very small leaves. Symptoms of rosetting and necrosis developed only from grafting Improved Bronze Daisy on Dynamo, not from grafting recovered Dynamo on healthy Dynamo. Good News was susceptible, but rarely expressed symptoms within 6 weeks. An interveinal speckling, and sometimes a well-defined interveinal mottling (Fig. 1B), developed after 6 to 12 weeks, especially in spring. Similarly, Golden Mistletoe usually remained symptomless for 6 weeks or more, but it developed veinbanding symptoms after 6 to 12 weeks. September Morn was susceptible but symptomless. The virus was recoverable from Good News, Golden Mistletoe, and September Morn.

Improved Bronze Daisy mosaic virus was not sap-transmitted from Dynamo to Dynamo, but 3 of 10 plants were infected by the fresh-leaf method in April, with blotching, epinasty, and mild rosetting appearing in 3 to 8 weeks. Myzus persicae failed to transmit it in two trials. This virus produced local lesions in petunia and was reisolated from petunia in 3 of 5 Dynamo. It infected cineraria without symptoms. On reisolation from cineraria it produced yellow local lesions but no systemic infection in 5 of 5 Good News plants, and veinbanding and epinasty in 4 of 5 Dynamo plants. Myzus persicae failed to transmit this virus from cineraria to Dynamo.

Improved Bronze Daisy mosaic virus was superimposed by graft on September Morn mosaic virus, and was reisolated unchanged.

When mosaic-affected Improved Bronze Daisy plants were held at 35° C and tip scions tested on Dynamo, none were found virus-free after 1 to 2 months, 1 of 3 after 3 to 4 months, and 3 of 3 after 5 to 6 months.

September Morn Mosaic Virus

The varieties September Morn (Yoder Bros. 1953) and Thanksgiving Pink were supplied by C. J. Olson in December, 1954, with the notation that these reacted as positive in Dynamo and as negative in Good News, in his graft-index tests. The two varieties, both symptomless, reacted alike in our tests, and September Morn was retained as the type source of the virus present.

September Morn mosaic virus produced no symptoms in Blanche, Blazing Gold, Good News, and Golden Misteltoe, and the virus was not recovered from the 3 last-named varieties. On graft inoculation to Dynamo this virus produced diffuse yellow blotches in mature leaves after 4 to 6 weeks, and mild yellow veinbanding in some young leaves after 6 to 7 weeks.

The virus was not transmitted to Dynamo by sap inoculation or by Myzus persicae. It produced yellow- to brown-spot local lesions in Velvety Blue petunia after 2 to 4 weeks and yellow local lesions in Heavenly Blue petunia in 3 weeks. The virus was not reisolated in Dynamo from the Heavenly Blue variety. It produced no symptoms in cineraria and was not recovered in Dynamo from this plant. No attempt was made to reclaim healthy tips from this variety by heat treatment.

John Cooper Mosaic Virus

The variety John Cooper, imported from England in 1954 and grown one season in a Pennsylvania nursery, expressed veinbanding in one of three plants in October, 1955. It is uncertain whether the virus present is of English or of local origin.

John Cooper mosaic produced no effect on graft inoculation to Blanche, Blazing Gold, and Dynamo; subinoculation to Good News from the two last-named varieties failed to recover the

virus. On grafted Good News this virus caused conspicuous epinasty and yellow stippling in about 1 month, followed by yellowing, leaf dwarfing, distortion, mosaic (usually interveinal), slight rosetting, and leaf and bud blast (Fig. 2C). In Golden Mistletoe, yellowing, leaf dwarfing, distortion, and rosetting of shoots appeared after 3 to 5 months. This virus infected September Morn without symptoms and was recovered unchanged.

John Cooper mosaic virus was not transmitted to Good News by sap or by Myzus persicae in May, 1956, and not by sap or the fresh-leaf method in June, 1957. It failed to infect Velvety Blue and Heavenly Blue petunias, and could not be recovered in Good News from the latter. It caused no symptoms in cineraria and was not transmitted from inoculated cineraria to Good News by sap or by Myzus persicae. Sunbeam chrysanthemum from England received in February, 1957, by H. M. Cathey, carried a virus similar to John Cooper mosaic virus in the test variety Good News.

Healthy plants of John Cooper were readily reclaimed from diseased ones by heat treatment. When infected plants were placed at 35° C, and tip scions were tested by grafting to Good News, 4 of 5 were healthy after 1 month of exposure, and 3 of 3 were healthy after 2, 3, and 4 months. Sunbeam was also held at 35°, and healthy tip scions were recovered on Good News as follows: 0 of 2 after 1 month, 2 of 3 after 2 months, 1 of 3 after 3 months, and 3 of 3 after 4 months.

"Hinckley" Mosaic Virus

In November, 1955, four plants of an unidentified variety of chrysanthemum, here called the "Hinckley" variety, were collected from an isolated farm garden in Hinckley, Ohio, where they had grown for many years without introduction of other varieties. By indexing these four plants, none of the more common chrysanthemum viruses were found, but one plant yielded the virus herein called "Hinckley mosaic virus."

Hinckley mosaic virus produced no symptoms in Blanche. In Blazing Gold it caused veinbanding in 3 months, and this pattern persisted unchanged to 6 months. In Dynamo, yellow blotches and veinbanding appeared after 1 month, persisting unchanged. In Good News, mosaic symptoms, often of veinbanding type, appeared after 1 month. Yellowing, leaf dwarfing, distortion, and rosetting appeared after 2 months (Fig. 2B), and the mosaic patterns became interveinal. Necrosis of leaves and stems followed after 3 months. Flowers of affected Good News were much reduced in size, with ray florets short, incurved, and streaked with brown. Golden Mistletoe grafted to infected Good News expressed veinbanding in 1 month, and epinasty, yellowing, rosetting, leaf dwarfing and distortion, interveinal mosaic, and necrosis of leaves and stems after 2 months. The virus infected September Morn without symptoms, and was reisolated.

Hinckley mosaic virus failed to infect Good News by sap inoculation or by Myzus persicae transfer in May, 1956; transmission by sap and by the fresh-leaf method failed again in June, 1957. This virus failed to infect Velvety Blue and Heavenly Blue petunia; reisolation from the latter failed in Good News. It caused no symptoms in cineraria; on subinoculation from cineraria to Good News, local lesions of the mosaic type (Fig. 1A) appeared in 5 of 5 plants in 1 month, and veinbanding developed in 1 of 5 after 2 months, early symptoms resembling those of Nightingale mosaic virus. After 4 months the yellowing and rosetting symptoms reappeared, and interveinal mosaic became conspicuous. All the usual symptoms of Hinckley mosaic virus were thus expressed by the virus recovered from cineraria, with the yellow mosaic symptom seemingly intensified by passage through this plant. Although the yellowing symptom induced in Good News is suggestive of a yellow-type virus, Cuscuta campestris Yuncker failed to transmit any virus from the Hinckley chrysanthemum to Vinca rosea L.

Hinckley mosaic virus was highly resistant to heat. Scions taken from affected plants, held at 35° C and tested on Good News, were undiminished in infectivity after 1 to 9 months of exposure to heat. One of 3 proved healthy after 10 months, 2 of 3 after 11 months, and 3 of 3 after 12 months.

Ivory Seagull Rosette Virus

The variety Ivory Seagull, carrying this virus without symptoms, was supplied by C. J. Olson in July, 1950. A similar virus accompanies the mosaic virus in Blanche. Reactions suggestive of Ivory Seagull rosette virus have been noted on indexing chrysanthemums from Michigan and New York, in combination with mosaic or with stunt virus. Since no specific test is known for detecting this rosette virus in the presence of more infectious viruses, its

distribution and prevalence remain obscure.

Ivory Seagull rosette virus produced no symptoms in Blanche, and Blanche scions had no effect on Ivory Seagull. In Blazing Gold, yellow veinbanding and crinkling appeared after 1 month; leaf dwarfing and distortion with a loose rosetting of shoots, followed after 3 to 6 months; flowers were smaller and slightly irregular. In Dynamo a dull-yellow interveinal mottling appeared after 1 month, remaining unchanged after 6 months. In Good News a dull-yellow mottling, with leaf dwarfing, developed in 2 months; tight rosetting (Fig. 2D) followed after about 6 months. Rosetting appeared earlier if plants were cut back. Flowers on affected plants were small and irregular. In Golden Mistletoe, yellow veinbanding with leaf distortion appeared in 3 to 4 months; rosetting followed in 7 months; affected flowers were small and of inferior quality. September Morn developed no symptoms in flowers or vegetative parts after grafting to Ivory Seagull. This rosette virus was reisolated unchanged from September Morn. Friendly Rival carried the rosette virus through two flowering periods without symptom expression.

Ivory Seagull rosette virus was sap-transmitted from Ivory Seagull to 1 of 10 Good News plants; by the fresh leaf method it was transferred from infected Good News to 3 of 10 Good News plants. The virus failed to infect petunia. It was sap-transmitted to cineraria, in which it caused no symptoms, but from which it was transmitted to 3 of 10 Blazing Gold plants. Myzus persicae failed to transmit this virus.

Ivory Seagull rosette virus is resistant to heat. Scions taken from mother plants held 2 to 6 months at 35° C transmitted the virus with undiminished virulence to Blazing Gold test plants.

Yellow Rayonante Rosette Virus

In October, 1956, C. J. Olson supplied Yellow Rayonante and White Rayonante, with the notation that these symptomless varieties, when grafted to Blanche, produced the flecking previously noted as a reaction to the Superlative mosaic complex. Since scions of these two varieties caused similar reactions in the usual test plants, Yellow Rayonante was retained as source of this rosette virus. No other sources of this rosette virus are known to us except that Superlative and several renamed English varieties appear to carry this rosette or a very similar virus, together with a mosaic virus. Scions of Superlative had no effect on Yellow Rayonante, but scions of the latter depressed the growth of Superlative stocks and induced a dull-yellow interveinal mottling in their leaves.

Yellow Rayonante rosette virus induced flecking in Blanche after 4 to 6 weeks. These flecks were a little later in appearing, and slower to become necrotic, than those induced by the Superlative mosaic complex. No abnormality in Blanche flowers accompanied either virus. In Blazing Gold the Yellow Rayonante rosette virus after 1 month caused veinbanding, epinasty, marked leaf distortion, and blistering; after 2 months, rosetting (Fig. 2F), with leaf dwarfing, green blisters, and brown necrotic streaks in leaves; 4 months after December grafting a tight rosette with very small leaves developed, and terminal growth ceased. Blazing Gold grafted to Yellow Rayonante in April developed only mild and transitory rosetting, followed by symptomless regrowth; rosetting reappeared in September. In Dynamo, veinbanding appeared in 10 weeks and rosetting in 4 months. In Good News, yellow veinbanding developed in 1 month, becoming interveinal mosaic with leaf dwarfing and distortion after 2 months; rosetting and general yellowing were evident after 3 months. In Golden Mistletoe both veinbanding and interveinal mosaic with leaf dwarfing and distortion appeared in 1 month, and there was leaf necrosis in 2 months. Infected plants of September Morn are shorter than normal, with normal flowers but with leaves mottled bright yellow except along the green veins. Yellow Rayonante rosette virus is the only one of the group herein discussed to produce symptoms in September Morn, from which it was recovered unchanged.

Yellow Rayonante rosette virus failed to infect tobacco, Nicotiana rustica, or petunia. It caused no symptoms in cineraria, and, unlike Ivory Seagull rosette virus, could not be reisolated from that plant. It was transmitted to 4 of 10 Blazing Gold plant by sap, and to 3 of 10 by the fresh-leaf method, in April, 1957. Yellow Rayonante scions induced transitory rosette symptoms in Ivory Seagull, as well as yellow blotches in leaves.

Yellow Rayonante rosette virus was resistant to heat. Scions taken from mother plants held 1 to 5 months at 35° C transmitted the virus with undiminished virulence to Blazing Gold test plants. Yellow Rayonante and White Rayonante were injured more than other varieties tested by continuous exposure to heat; tests therefore could not be continued for more than 5 months.

DISCUSSION

The variety Blanche reacts characteristically to the viruses of stunt (8), flower distortion (6), and Yellow Rayonante rosette at all seasons; it responds to aster yellows virus with well-defined rosette symptoms in winter, but not in summer. It fails to react to any of the chrysanthemum mosaic viruses in the absence of accompanying rosette viruses, and as a test variety has the disadvantage of carrying two viruses itself.

Blazing Gold is a good indicator for stunt virus, developing a narrow yellowish veinbanding after 5 to 6 weeks at all seasons. Blazing Gold forms rosettes in response to flower-distortion virus (6) at all seasons, and in response to aster yellows virus in winter but not in summer. It is a sensitive reactor to each of the rosette viruses except in summer. It reacts to Hinckley mosaic virus, but resists some other mosaic viruses and carries still others without symptoms.

Dynamo is useful chiefly as an indicator variety for the mosaic viruses from September Morn and Improved Bronze Daisy. It is inferior to other test varieties for detecting the viruses of other mosaics, rosettes, stunt, aster yellows, and flower distortion.

Good News is a poor indicator for stunt virus, developing transitory vein-clearing in 5 to 6 weeks. It reacts poorly or tardily to aster yellows and flower-distortion viruses, but is one of the best indicators for the viruses of mosaics and rosettes. Good News tends to differentiate the various mosaic viruses more clearly than other test varieties. It responds to the rosette viruses in summer, when Blazing Gold reactions are poorly defined.

Golden Mistletoe (also Bronze, Pink and White Mistletoes) is an excellent stunt virus indicator except for two disadvantages. First, the distinctive yellow leaf spots ("measles") are smaller and fewer in winter and sometimes are lacking (3). If 300-watt Mazda lamps are placed and operated as for photoperiod control, this variety is a satisfactory stunt indicator in winter also. Second, Golden Mistletoe occasionally develops an unexplained leaf spotting that closely resembles the early stages of stunt virus expression. These "wild" spots remain small, and do not simulate the later stages of stunt symptoms. The Mistletoe varieties do not respond to aster yellows or flower-distortion viruses soon enough to make them useful indicators; they express symptoms of the various mosaics and rosettes but do not distinguish them from each other as well as does Good News.

Symptomless carriers are extremely common in chrysanthemum. Many varieties such as Blanche, Yellow Rayonante, White Rayonante, Ivory Seagull and Superlative, are acceptable for commercial use although carrying viruses capable of severely damaging other chrysanthemum varieties. The use of these carrier varieties has led to no commercial losses; indeed, no losses are to be expected in greenhouse culture, since these viruses are not transmissible by handling or by any known vector. It is conceivable that such latent viruses might cause losses in outdoor plantings, where undiscovered vectors may be operative. The variety September Morn (Yoder Bros. 1953) is an outstanding example of virus tolerance or carrier capacity. All of the mosaic viruses and one of the rosette viruses discussed herein can invade September Morn without producing recognizable symptoms.

Blazing Gold is immune from or resistant to five of the mosaic viruses, for these could not be recovered from it by backgrafting. This suggested that the variety might be a screening host for separating rosette viruses from accompanying mosaic viruses. However, the mosaic components present in Superlative and Blanche, together with rosette components, were not eliminated by passage through Blazing Gold. It may be assumed that these mosaic viruses differ from those described in this paper, or that they infect Blazing Gold more readily when accompanied by another virus highly infectious to the variety.

The mosaic viruses in the Good News and Hinckley varieties, when first reisolated from cineraria, appeared to be reduced in virulence, suggesting that these might be complexes. However, when these reisolated viruses were held in Good News 3 months or longer, the full range of symptoms reappeared with original virulence.

In attempting to reclaim healthy tip cuttings or scions from heat-treated virus-diseased chrysanthemums, it is advisable to index the selected tips on reliable test varieties because time-temperature combinations are not sufficiently uniform in effect to be dependable. Furthermore, it is advisable to hold the graft index tests for three or four times the normal period for symptom expression. This permits detection of virus of very low titer. The objective is to permit shoot growth at a temperature too high for virus multiplication. In practice a trace of virus is frequently still present in the cutting or scion selected; detection of a trace of virus may take more than twice as long as detection of the same virus at high titer. In spite of the unsatisfactory temperature control attained in our chamber, we were able to reclaim healthy

tips from chrysanthemums infected with aspermy, aster yellows, and flower-distortion viruses (6), as well as from the mosaic-infected plants reported in this paper. We had no success in reclaiming healthy tips from stunt-affected White Mistletoe after 1 to 7 months at 35° C.

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STUDIES ON RED LEAF DISEASE OF LOWBUSH BLUEBERRIES[1]

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Abstract

Exobasidium vaccinii (Fuckel) Wor. was isolated from lowbush blueberries and cultured on Czapek's nutrient agar. The minimum, optimum and maximum temperatures for growth of the fungus were 6.5°, 20° to 24°, and 32.8°C with an optimum for spore germination of 21°. Pathogenicity tests showed that new red leaf symptoms appeared on branches arising from the main stem at the end of 3 months and on shoots arising from the rhizome in 7 months.

Observations during a 2-year period indicated that the number of infected shoots increased between the first- and second-crop years; that some of the infected shoots died each year, and also that the fruit set was reduced. Experiments with fungicides and antibiotics gave negative results and the only means of control at the present time is eradication of the diseased blueberry plants with a herbicide.

INTRODUCTION

Red leaf is a systemic disease of lowbush blueberries, Vaccinium myrtilloides Michx. and V. angustifolium var. laevifolium House and var. nigrum (Wood) Dole, caused by Exobasidium vaccinii (Fuckel) Wor. The disease occurs on blueberries in the eastern provinces of Canada and in the United States from Maine to New Jersey. Recently it has become serious in many of the newly developed blueberry fields in Nova Scotia.

Exobasidium vaccinii has been known on various species of Vaccinium for some time. Woronin (5) first investigated it on Vaccinium vitis-idaea L. Graafland (1) cultured E. vaccinii on artificial media from Vaccinium vitis-idaea but there are no reports in the literature of the isolation of E. vaccinii from the lowbush blueberries.

Hilborn and Hyland (2) found that red leaf infection occurred by direct penetration through the cuticle of the blueberry stem, and that mycelium was perennial in the rhizome and present in the shoot buds arising along the rhizome. They suggest that this mode of infection may explain the rapid spread of red leaf disease in blueberry fields which previously showed only a trace of the disease.

According to Woronin (5) local hypertrophies, similar to those found under natural conditions, develop on the foxberry 2 to 3 weeks after inoculation. Such hypertrophies are seldom found on the blueberry. Typical symptoms of red leaf on blueberries are reddening of the foliage with a white feltlike layer of mycelium, and spores on the under surface.

The studies reported in this paper include: 1) isolation and culturing of Exobasidium vaccinii; 2) effect of temperature on the growth and germination of the fungus in vitro; 3) pathogenicity tests to determine the developmental cycle of the fungus; 4) growth of shoots from rhizome cuttings taken from infected plants; and 5) losses and control.

ISOLATION OF THE FUNGUS

Numerous attempts to isolate E. vaccinii from platings of surface-sterilized sections of leaves were unsuccessful, but it was found that the fungus could be isolated from infected blueberry leaves using the method described by Stover and Waite (4). This method consisted of surface sterilizing approximately 50 leaves with mercuric chloride 1:1000 for 2 minutes and then macerating them in sterile distilled water in a Waring Blendor. One cubic centimeter of the suspension was pipetted to each of a series of Petri plates containing Martin's (3) peptone-dextrose-agar, rose bengal, and Agri-mycin 100. At the end of 2 weeks colonies of the fungus were transferred to Czapek's nutrient agar. Growth on Czapek's and P.D.A. was slow but spore production was abundant. Repeated attempts to isolate the fungus from apparently infected stems

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and rhizomes, by the above method, were unsuccessful.

EFFECT OF TEMPERATURE ON GROWTH AND SPORE GERMINATION

The effect of temperature on the growth of the fungus was determined on Czapek's nutrient agar plates incubated at eight different temperatures ranging from 0° to 32°C. After 28 days the diameter of the colonies was measured. The results are presented graphically in Fig. 1.

Spores were scraped from infected leaves and suspended in distilled water to determine the temperature range for germination. One drop of this suspension was applied to a hanging-drop microscope slide. The slides were incubated at eight different temperatures ranging from 0° to 32°C. After 24 hours of incubation the percent germination was determined. The test was run in duplicate and repeated on different days. The results were averaged and are presented in Fig. 1.

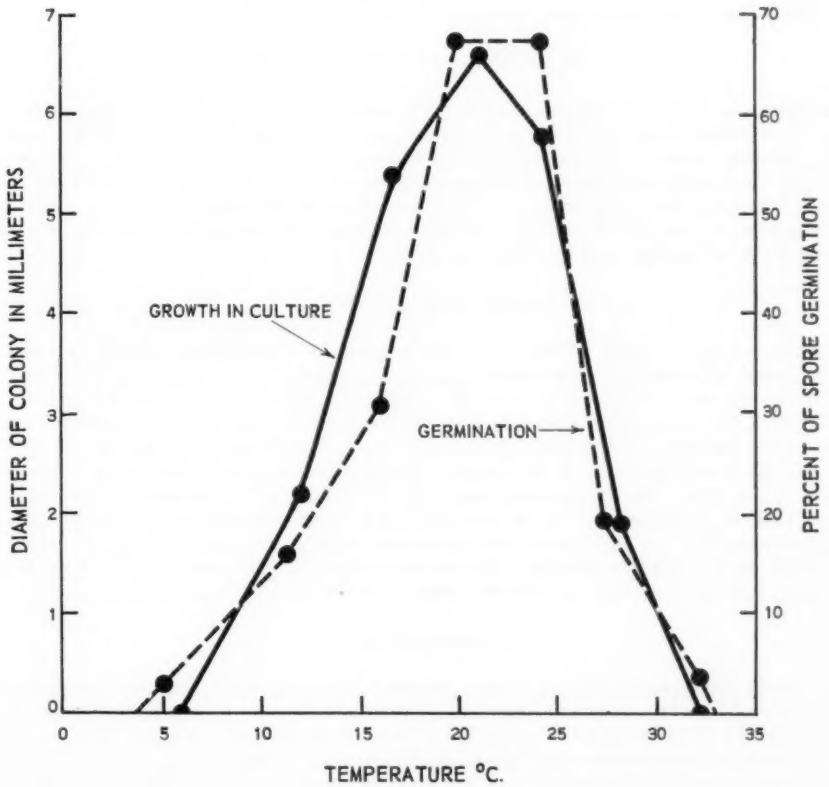

FIGURE 1. Influence of temperature on growth and spore germination of Exobasidium vaccinii.

PATHOGENICITY TESTS

Pathogenicity tests were carried out in the greenhouse; spores were secured from infected blueberry leaves and also from artificial cultures. Blueberry plants showing a new succulent growth were inoculated by atomizing with a spore suspension and by direct inoculation of wounds. Those atomized with aqueous spore solutions were kept in a moist atmosphere from 3 to 14 days. Wound inoculations were kept moist with the aid of moistened cotton batting held in place over the wounds with cellulose tape for 72 hours.

Examinations of the atomized leaves revealed that at the end of 3 days spores had germinated on the surface of the blueberry leaf and penetration of the leaf had occurred.

Two to three weeks after the blueberries were inoculated by atomizing, nonsporulating flecks occurred on the foliage but typical red leaf symptoms were reproduced only after a period of 3 months on leaves of new side branches which had developed near the base of the main stem. After a period of 7 months typical red leaf symptoms were produced on new shoots arising from the rhizome of the originally inoculated plants. Intensity of infection appeared to be related to length of the incubation period. Plants held in the moist chamber for 14 days were the most heavily infected.

Those plants which were wound-inoculated developed symptoms after a period of 6 months on subsequent shoots arising from the rhizome. There was no difference in the pathogenicity of spores taken from infected leaves or from artificial cultures.

THE FUNGUS IN THE RHIZOME

Rhizomes from severely infected plants were collected in July and rhizome cuttings, 5 inches long, were taken from the base of each infected shoot to determine if the causal fungus was always present in the rhizomes of infected blueberry clones. These rhizomes cuttings were immediately potted in a mixture of compost soil and peat, and grown in the greenhouse. At the end of 5 months 64 percent of the rhizomes had produced shoots showing red leaf symptoms. Seventeen percent of the cuttings did not grow and 19 percent produced healthy shoots. The latter were still healthy at the end of one year.

LOSSES AND CONTROL

Data taken during a 2-year period from 22 experimental spray and dust plots established on clones infected with red leaf showed that infection ranged from 11.7 to 31.1 percent of the shoots in first-crop year and from 16.7 to 37.8 percent of the shoots in the second-crop year. Of these, from 4.5 to 28.4 percent of the shoots died between the first- and second-crop years.

Fruit production may be reduced by the disease. In the first-crop year from 10.9 to 27.5 percent of the red leaf shoots set fruit compared with an average of 33 percent of the shoots in the healthy control area. In the second-crop year from 1.7 to 7.8 percent of the diseased shoots bore fruit in comparison with 16 percent of the healthy shoots in the control area.

Attempts to prevent the spread of red leaf in the field by the use of fungicides and antibiotics have so far given negative results. Eradication of red leaf blueberry plants with a mixture of 2,4-D and 2,4,5-T, in water, is the only means of control at the present time.

DISCUSSION

In this study, Exobasidium vaccinii was isolated from blueberry foliage and cultured on artificial media. Attempts to isolate this fungus from stems and rhizomes were unsuccessful.

The data in Fig. 1 show that the optimum growth of the fungus occurred at about 21°C and the optimum temperature for spore germination occurred between 20° and 24°C.

The pathogen was found to grow down the stem into the rhizome. Red leaf symptoms were not produced on inoculated leaves but only appeared after a period of 3 to 7 months on subsequent foliage of the shoots arising from either the inoculated plants or the rhizomes. This long incubation period would partly explain the apparent slow spread of this disease in the field.

Because of the systemic nature of the disease there is need of a search for a systemic fungicide or antibiotic to be used in severely infected fields. In fields not severely infected it is economical to eradicate diseased plants by means of a herbicide.

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RACES OF AND RESISTANCE TO PHYTOPHTHORA FRAGARIAE

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Abstract

Ten isolates of Phytophthora fragariae Hickman obtained from a small area on the Saanich peninsula of Vancouver Island varied widely in their pathogenicity on some common strawberry varieties. An isolate from loganberry was the least pathogenic. No correlation could be detected between pathogenicity and morphology of isolates. The possible origins of new races which appeared in an infested soil after planting of a resistant variety are mentioned. The varieties British Sovereign and Perle de Prague were resistant to certain isolates even though they were not bred for resistance to red stele. The importance of testing new red stele resistant varieties with several races is indicated. Common indicator plants for determining races and a uniform racial numbering system would be helpful in the red stele problem.

During the past 20 years strawberry workers in North America have found that red stele or red core of strawberries is present in most strawberry plantations except in southerly regions where winters are warm. Because the pathogen, P. fragariae, is sensitive to dryness and high temperatures it is capable of inciting disease only during the cool, wet season and remains dormant in the oospore stage throughout the summer.

In the coastal regions of British Columbia environmental conditions are ideal for the development of the red stele organism from October until March, at which time the disease subsides. Because moisture and temperature are still suitable for disease development while the strawberry plant commences to recover it is believed that a factor for resistance or some inhibitor begins to express itself. Recovery or increased resistance may be influenced by a change in the physiology of the host at this time of year. The author obtained a slight indication that spraying of sucrose on leaves of plants tended to increase their resistance.

The occurrence of races of P. fragariae has been reported by strawberry investigators (2, 3, 5, 6, 8). Because the prevalence and distribution of races is exceedlingly important in breeding and selecting suitable strawberry varieties for commercial production, the author decided to study 11 isolates of P. fragariae which he isolated during the winter 1954-55 as described in a previous article (4).

METHODS

Nine isolates were obtained from strawberries within a 20-square-mile area on the Saanich peninsula of Vancouver Island, one from loganberry in the same area and one from strawberry on Lulu Island at the mouth of the Fraser river.

In order to conduct pathogenicity tests isolates of P. fragariae were multiplied in flasks containing an oatmeal-sand mixture which, after sufficient development of the fungus to assure infestation, was mixed in steamed greenhouse soil. Young root-rot free strawberry plants produced by the method described by van Adrichem and Bosher (1) were transplanted into the inoculated soil which was kept in flats in a refrigerated room at a temperature of approximately 50°F. To assure that the pathogen was present and virulent a few Baron von Solemacher plants, a very susceptible host, were placed in all flats. Twelve plants of each variety were tested in two experiments. The soil was kept wet and artificial illumination was used. Plants that had only about 10 percent of their small roots infected were considered slightly susceptible.

RESULTS AND CONCLUSIONS

The type of soil and host variety from which each isolate was obtained is given in Table 1.

From the results given in Table 2 it will be noted that the pathogenicity of the 11 isolates and the susceptibility of the strawberry varieties used varied greatly. Not only were the Huxley and Baron von Solemacher varieties completely susceptible but so also were the strains of

Table 1. The type of soil and host variety from which each isolate of Phytophthora fragariae was obtained on the Saanich peninsula.

Isolate Number	Host variety	Soil type
M1	Loganberry	clay
M2	British Sovereign	clay
M3	Northwest	sand-loam
M4	Climax	muck-clay
M5	British Sovereign	loam
M6	British Sovereign	sand-loam (hill)
M7	British Sovereign	sand-loam
M8	British Sovereign	sand-loam
M9	4501 (Saanichton)	sand-loam
M10	Redcrop	muck-clay
[a]M11	British Sovereign	muck-clay

[a]obtained from Lulu Island

Table 2. The susceptibility of several strawberry varieties to 11 isolates of Phytophthora fragariae.

Isolate Number	F. virginiana, F. ovalis, F. chiloensis, Huxley Baron von Solemacher	Perle de Prague	British Sovereign	Aberdeen	Stelemaster	Md. 683	Climax	Siletz
M1	S	-	R	R	R	R	R	R
M2	S	S	S	S	R	R	R	R
M3	S	S	S	SL	SL	R	R	SL
M4	S	SL	R	SL	R	R	S	R
M5	S	SL	S	SL	R	R	R	SL
M6	S	SL	S	R	R	R	SL	R
M7	S	R	S	R	S	R	R	SL
M8	S	SL	S	R	R	R	R	R
M9	S	SL	S	R	R	R	R	R
M10	S	SL	R	R	SL	R	SL	R
M11	S	R	S	R	R	SL	SL	R

R = resistant
SL = slightly susceptible
S = susceptible

the three species used. However, resistance has been obtained from both F. virginiana and F. chiloensis (7, 10).

It is interesting to observe that the British Sovereign variety, the most popular commercial variety in British Columbia which was produced and selected by a Japanese grower in that province, has resistance to three different isolates -- the loganberry (M1), the Climax (M4), and the Redcrop (M10) isolate. Although the British Sovereign variety was not bred for resistance to the red stele fungus, the fact that it carried resistance probably aided its popularity. Both M4, the Climax isolate, and M10, the Redcrop isolate, were taken from a small plot of land which had been planted previously with the British Sovereign variety but because of the severity of the red stele disease had to be replaced by resistant varieties. Neither M4 nor M10 are pathogenic to British Sovereign. These two races may have been introduced with their host or possibly were surviving on some weed hosts. Perhaps these races, M4 and M10, developed after the introduction of the resistant hosts.

Perle de Prague is similar to British Sovereign in that it carries some resistance even though it was not bred for resistance.

Md683, which carries the Scottish type of resistance (8) obtained from the variety Scotland BK46, was resistant to all the isolates with the exception of M11 and was the most resistant of all the varieties tested.

Aberdeen, the original American source of resistance, was susceptible to M2 through M5.

An attempt to combine the American and Scottish type of resistance was undertaken in the production of Stelemaster (Fairland x Md683) (9) and Climax (Aberdeen x F_2 of No. 52 [Firth]) (6) but it will be observed that some resistance was lost in the production of these varieties, probably owing to the fact that a number of races was not used in the breeding program. Since the commercial strawberry is an octoploid and resistance is qualitative it is impossible to detect the loss of resistance if the progeny is tested in one soil type which may contain only one race. Thus a variation of resistance between Fairland, Redcrop, Sparkle and Temple, commercial red stele resistant varieties which have the same parents (Aberdeen and Fairfax), might be expected.

M3 and M5 are very similar in their pathogenicity and were the most pathogenic isolates, while M1 (Loganberry isolate) is the least pathogenic. M8 and M9 are identical. M4 and M7 were distinct morphologically from the other nine isolates owing to the presence of spherical swellings on their mycelium, but their host range was entirely different.

At least M1, M2, M3, M4, M7 and M10 are distinct pathologically and might better be called races C1, C2, C3, C4, C5 and C6 respectively.

This study indicates that the strawberry red stele problem is extremely complex and it might be helpful if the red stele investigators decided upon common indicator plants for determining races. A uniform racial numbering system would be most helpful in advancing our knowledge of this fungus.

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LEAF BLOTCH AND PETIOLE BLIGHT OF STRAWBERRY CAUSED BY GNOMONIA FRUCTICOLA[1]

M. C. J. van Adrichem and J. E. Bosher

Abstract

Damage caused by Gnomonia fructicola (Arnaud) Fall is severe in some strawberry plantations on Vancouver Island. The leaf symptoms consist of pin-point lesions and blotches. Petioles infected with blight show a black discoloration girdling the petioles. No infection was found in the crowns of infected plants. Numerous necks of the perithecia could be observed on the infected tissues. Inoculations of the leaves, petioles and inflorescences of strawberry plants proved to be successful. Inoculations of strawberry roots were unsuccessful. Recent changes in cultural practices are thought to accentuate losses due to G. fructicola.

INTRODUCTION

During the summer of 1957 a dying of the outer leaves was observed on the strawberry variety Sierra in the laboratory field test plots at Saanichton, British Columbia. Since this variety is highly resistant to Verticillium wilt and the symptoms closely resembled those of Verticillium wilt, some petioles of infected plants were selected for further study. The petioles were placed in moist chambers and after a week to 10 days numerous yellowish-brown pycnidia developed on the surface (Fig. 5). These pycnidia were plated on potato-dextrose agar and after a few weeks numerous perithecia, similar to those described by Fall (3) as perithecia of Gnomonia fructicola (Arnaud) Fall, were produced (Fig. 4).

The disease has since been observed as a leaf blotch on the strawberry variety British Sovereign, and as a petiole blight on the varieties British Sovereign, Northwest, and Agassiz.

In a 1-year-old planting of British Sovereign petiole blight killed all the leaves on 5 percent of the plants (Fig. 2). In a 2-year-old planting, which was very weedy, the leaf blotch phase killed over 90 percent of the old leaves. In a 3-year-old planting leaf blotch lesions were observed on approximately 99 percent of the young leaves in early March.

The pathogen was first recorded in Canada by Fall (3), who isolated the fungus from lesions on strawberry leaves. Bolton et al. (2) report that in Eastern Canada the incidence of the disease in most cases is negligible, but that in 1951 it killed about 5 to 10 percent of the plants in a few plantations. In 1948 Alexopoulos and Cation (1) isolated a Gnomonia sp., considered by Fall (3) to be G. fructicola, from strawberry fruit. Wormald (England) (5) reported the disease in 1941 on leaves and petioles. Wilhelm (4) states that G. fructicola is commonly found in platings of Rhizoctonia-infected strawberry tissue. However, he does not describe any definite damage due to this pathogen. The authors believe this to be the first record of the disease in Western Canada.

SYMPTOMS

The light-brown color and eventual killing of the older leaves are characteristic field symptoms of the disease. Pin-point lesions and blotches on the younger leaves are also characteristic (Fig. 1). Microscopic examination of dead leaves and the blotched areas of the young leaves discloses numerous necks of the perithecia of G. fructicola. Black discolorations completely girdling the bases of the petioles are often indicative of infection. Quite frequently the discoloration extends into the laminae and in some cases the young leaves are also blackened. Older leaves become yellowed when infection involves the greater part of the petioles. The surface of the infected petioles exhibits many necks of the perithecia. In one field, covered with a sawdust mulch approximately 3 inches deep, no perithecia were found in plant tissues covered by the sawdust, although they were numerous in the tissues above the mulch. The crowns of the plants were free from discoloration and no infection was found therein.

Petiole symptoms are not unlike those of Verticillium wilt, the distinctive feature

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[1]Contribution No. 1691 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

FIGURE 1. Pin-point lesions and leaf blotch (upper right leaf) caused by G. fructicola on the strawberry variety British Sovereign.

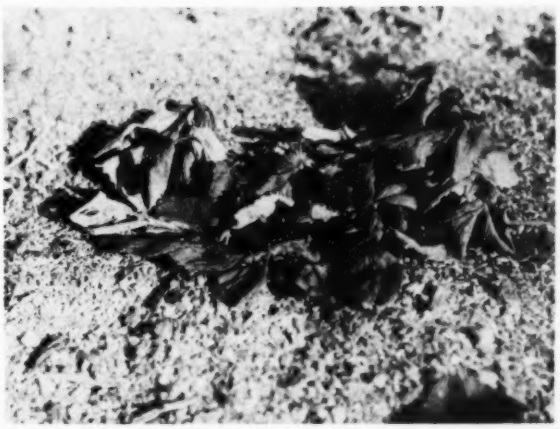

FIGURE 2. Strawberry plant of the British Sovereign variety severely infected with petiole blight. Note the resemblance to Verticillium wilt.

FIGURE 3. Pycnidia of G. fructicola on strawberry fruit.

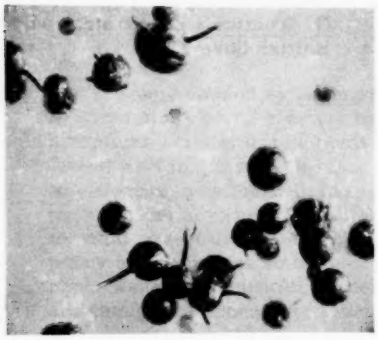

FIGURE 4. Perithecia of G. fructicola on potato-dextrose agar.

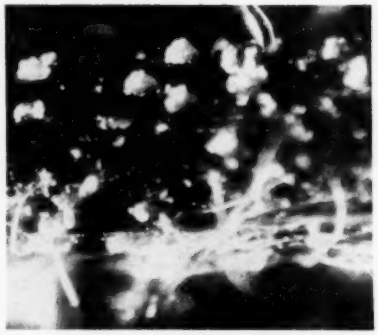

FIGURE 5. Pycnidia of G. fructicola on strawberry petiole.

of Gnomonia infection being complete girdling accompanied by black discoloration of the petioles whereas with Verticillium the blackening usually occurs in streaks. Fresh cut crowns infected by Gnomonia are white whereas those infected with Verticillium show a marked brown discoloration.

ISOLATION AND PATHOGENICITY

Isolates of the fungus were readily obtained by surface-sterilizing the petioles or leaves with a 1 percent sodium hypochlorite solution and placing them in moist chambers to allow the pycnidia to develop. Development of pycnidia usually required 7 to 10 days. The spores which formed in the pycnidia were readily transferred to agar plates by running a few drops of sterile water over the petioles onto the plates. The organism was also readily transferred from the petioles to agar plates by dipping a sterile scalpel into the refractive droplet that frequently appeared at the tip of the beaks of the perithecia and streaking it across the plates. These refractive droplets contained an abundance of ascospores. Cultures from conidia or ascospores produced both pycnidia and perithecia on potato-dextrose agar at room temperature.

Plant of Fragaria glauca were used in pathogenicity tests. The inoculum in sterile water was distributed over the plants by an atomizer and highly humid conditions were maintained by the use of plastic covers. After 4 weeks, numerous pin-point lesions developed on the leaves and petioles. The bases of the outer petioles were the most heavily infected. The plastic coverings were then removed, and after 3 months an abundance of pycnidia and the typical symptoms of the disease were evident.

Under controlled conditions of high humidity, inoculations of the inflorescences were successful. This was accomplished by dipping inflorescences at several stages of development into a mixed suspension of conidia and ascospores. The symptoms of initial infection appeared in 7 to 10 days as localized browning of the pedicels, usually just above the calyx. In many cases, the fungus appeared to enter the calyx, progressing from the calyx into the fruit, completely killing the berries. One of the fruits, which was pale green when inoculated, showed when ripe a great number of pycnidia on one side of the berry (Fig. 3).

Root inoculations were unsuccessful. Small runner plants were transferred to soil heavily inoculated with the fungus and in no case did the disease develop or did discoloration occur on root tissues.

DISCUSSION

Blotch and petiole blight caused by G. fructicola has only recently appeared as an important disease in the strawberry plantings of the coastal regions of British Columbia. This is attributed to the more general use of sprinkler irrigation than formerly and the application in some cases of sawdust mulches which tend to maintain a more humid microclimate around the plants. Our observations that G. fructicola infection is favored by heavy weed growth support those of Wormald (5) who has pointed out that moist, shady areas are conducive to the disease. The former practice of burning straw mulches which are applied to protect the fruit against dirt has been replaced by tilling in of the straw. The rapid postharvest burn of the straw mulch undoubtedly destroyed a large amount of inoculum, hence cessation of this practice has probably allowed more inoculum to accumulate, thus accentuating losses by G. fructicola.

ACKNOWLEDGMENTS

The authors are indebted to I. C. Carne, District Horticulturist, Abbotsford, B. C., for providing diseased plant material of the Northwest and Agassiz strawberry varieties, and to A. Craigmyle and J. Trelawny for the preparation of photographs.

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THE EFFECT OF SOME PESTICIDES ON THE CHEMICAL COMPOSITION OF McINTOSH APPLE LEAVES

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The fungicides and insecticides now being widely used in currently recommended spray programs for apples are entirely capable of adequately controlling the various plant diseases and insects. When the developmental costs of a new pesticide are taken into consideration, it becomes obvious that satisfactory pest control can almost be taken for granted, otherwise the chemical would never have reached the stage of commercial usage. However, it has been observed occasionally that although a spray chemical has become established in recommended spray programs, it may still cause injury under some conditions. One of the well known examples is the combination of glyodin and lead arsenate. Usually, in those orchard areas where lead arsenate is commonly used as an insecticide, the combination of these two spray chemicals gives adequate disease and insect control with a minimum of phytotoxicity. Yet seasonal conditions may affect the orchard performance of this particular spray combination, and over a period of years it has become recognized that a hot dry summer is conducive to foliage burning and fruit russetting.

Mitchell et al. (1) have shown that this spray injury may be caused by the formation of 2-heptadecylglyoxalidine arsenate when 2-heptadecylglyoxalidine acetate (glyodin) is added to lead arsenate. Some side reactions also take place which result in the release of acetic acid and arsenic acid. Either arsenic acid or 2-heptadecylglyoxalidine arsenate may cause severe injury to apple leaves, and Mitchell found that the addition of ferric sulfate would prevent the 2-heptadecylglyoxalidine acetate from reacting with arsenic acid to form the 2-heptadecylglyoxalidine arsenate and acetic acid. He suggested the use of ferric sulfate as a safeguard against possible phytotoxicity under field conditions. Palmiter (2) has shown that the use of ferbam, a fungicide known to contain iron, is also effective in correcting glyodin-lead arsenate injury.

Current studies at the Maine Experiment Station are concerned with the effect of various spray chemicals on disease and insect control and also the possible physiological effects the various pesticides and combinations of them may have on apple trees. In connection with this work, various analyses have been made of chlorophyll content of foliage, apparent photosynthesis and others which will be reported on later. However, in 1957 a spectographic analysis was made of McIntosh apple leaves which had been sprayed with various pesticides. The experiment was conducted in a block of 17-year-old Rogers McIntosh trees to which various spray treatments, consisting of two plots per treatment, were applied on randomized single-tree plots. The 1957 growing season was such that the trees made excellent growth and produced good crops unhampered by either disease or insect injury. The foliage was sampled late in August 1957 by collecting 100 leaves from the two trees in each treatment. These leaves were then analyzed for the various chemical constituents. The results are shown in Table 1.

If the various spray treatments are compared it is obvious that some chemical elements are increased while others are decreased by spray chemicals applied. It has long been recognized that the ratio of iron to manganese in plants should be close to 2:1 for good plant growth (3). If the iron-manganese ratio is calculated for these various treatments it is apparent that two of the treatments have a ratio approaching 1:1, which is considered to be approaching the toxic level in itself. These data are presented in Table 2.

Observations during the season showed that the foliage on the glyodin-lead arsenate and on the lead arsenate plots was substandard as compared with the foliage on all other treatments.

These data would suggest that spray injury from lead arsenate and glyodin-lead arsenate in combination may be due to the presence of arsenic acid and 2-heptadecylglyoxalidine arsenate and may also be due in part to a decrease in the iron-manganese ratio in apple leaves. Palmiter (2) found that the addition of manganese sulfate to the glyodin-lead arsenate mixture caused greater leaf injury than the glyodin-leaf arsenate mixture with no corrective. This may be a further indication of the iron-manganese imbalance associated with this injury. Perhaps the effectiveness of ferric sulfate or ferbam as correctives for spray injury in glyodin-lead arsenate mixtures may also be due, at least in part, to the absorption of iron by the leaf

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Table 1. Some chemical constituents of McIntosh apple leaves sprayed with various pesticides. Values in percent of dry weight determined spectrographically.

Element	Treatment							
	Captan	Captan + lead arsenate	Glyodin	Glyodin + lead arsenate	Sulfur	Sulfur + lead arsenate	Lead arsenate	Control
N	2.55	2.42	2.60	2.37	2.51	2.38	2.36	2.44
P	.10	.13	.11	.10	.14	.11	.15	.10
K	1.10	1.15	1.55	1.08	1.10	1.15	1.60	1.09
Cu	.0013	.0013	.0018	.0012	.0017	.0012	.0013	.0012
Fe	.0128	.0120	.0119	.0096	.0093	.0092	.0110	.0110
Mg	.40	.40	.31	.34	.41	.36	.33	.35
Mn	.0072	.0081	.0070	.0082	.0062	.0062	.0092	.0084
Ca	1.12	1.45	1.39	1.70	2.20	1.14	1.80	1.75
B	.0027	.0030	.0031	.0025	.0026	.0024	.0026	.0034

Table 2. The iron-manganese ratio of various spray treatments.

Treatment	Ratio	Foliage injury
Captan	1.78	None
Captan + lead arsenate	1.48	None
Glyodin	1.70	None
Glyodin + lead arsenate	1.17	Injured
Sulfur	1.50	None
Sulfur + lead arsenate	1.48	None
Lead arsenate	1.20	Injured
Control	1.31	None

and a subsequent increase in the iron-manganese ratio. This possibility will be investigated in the future.

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FLOURY LEAF SPOT (MANCHA HARINOSA) OF BEAN IN COLOMBIA[1]

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In 1953 a new leaf disease of dry beans (Phaseolus vulgaris L.) was observed in the breeding and experimental plots at the Colombian Ministry of Agriculture Experiment Station near Medellin. The disease did not appear to be of importance at the time because it was found on very few varieties and lines and its severity was negligible. In subsequent years, however, it became much more prevalent and severe, causing losses in commercial as well as in experimental plantings. Its name "mancha harinosa" or "floury leaf spot" refers to the characteristic sign on the reverse side of the infected leaves. The causal agent was identified as Ramularia phaseolina Petrak[3], which was first described by Petrak, in 1950, on P. vulgaris in Ecuador (1).

SYMPTOMS

Petrak's (1) description of the symptoms produced by Ramularia phaseolina is quite characteristic of those observed in Colombia. The name of the disease is derived from the white, tufty growth of the fungus conidiophores on the lower leaf surface which gives to the leaf the appearance of having been sprinkled with coarse flour (Fig. 1). This sign alone easily serves to distinguish floury leaf spot from any other bean disease known in Colombia.

Infection first appears on the lower leaves and progresses upward in the plant to all but the youngest leaves. The symptoms can be seen any time after the emergence of the first trifoliate leaves and severe infection causes premature defoliation. No symptom has been observed on any plant part except the leaves.

MORPHOLOGY

Ramularia phaseolina, according to Petrak (1), is quite typical of the genus and is distinguished, in part, by clustered or fasciculate conidiophores. After the latter emerge from the stomata, they grow along the lower epidermis of the leaf and down the leaf trichomes. Petrak did not observe this intertwining of the conidiophores around the trichomes. When several-to-many hyaline conidiophores thus grow around a trichome they produce what appears, upon cursory examination, to be a synnema (Fig. 2). It is this growth habit that gives the tufty appearance to the lower surface of an infected leaf.

The noteworthy similarities and differences between the conidiophores and conidia of Ramularia phaseolina from Ecuador and Colombia are shown in Table 1. The description in the Colombian column is given as an amendment to the original for the species.

NOMENCLATURE

Ramularia (Cylindrospora) phaseoli Klotzsch can be found in Sylloge Fungorum (2), but apparently no description of the fungus was given when it was reported on Phaseolus sp. in 1832. Saccardo considered R. phaseoli a nomen nudum. When Petrak (1) first described R. phaseolina he clearly and correctly stated that the identity of his species with R. phaseoli could never be clarified. The latter species should therefore be discarded.

DISTRIBUTION AND SEVERITY

Stevenson (3) stated that he has a collection of Ramularia phaseolina from Nicaragua, and Petrak (1) found the pathogen causing a destructive disease in Ecuador. Since 1953, when it was first found in Colombia, floury leaf spot has spread throughout the bean-producing regions at altitudes of 1500 to 2200 meters. A large part of the country's dry bean crop is produced within this range.

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[1]Paper No. 97 of the Agricultural Journal Series of The Rockefeller Foundation.

[2]Director of the Bean Improvement Program, Colombian Ministry of Agriculture, and Plant Pathologist with the Colombian Agricultural Program of The Rockefeller Foundation, respectively.

[3]The authors are indebted to J. A. Stevenson, United States Department of Agriculture, M. P. Backus, University of Wisconsin, and S. J. Hughes, Department of Agriculture, Ottawa, Ontario, Canada for invaluable aid in the identification of the fungus.

FIGURE 1. The lower surface of a bean leaf infected with Ramularia phaseolina. The lesions are irregular in outline and the white tufts of conidiophores that have grown around the trichomes, causing the characteristic floury appearance, can be seen within the lesions. The dark, angular lesions are caused by Isariopsis griseola and Cercospora vanderysti.

FIGURE 2. Diagrammatic drawing taken from camera lucida of a trichome, from the lower surface of a bean leaf, surrounded by intertwined conidiophores of Ramularia phaseolina. This growth habit somewhat resembles a synnema. Each white tuft that can be seen in Fig. 1 is one trichome with attached conidiophores.

Table 1. Comparison of Ecuadorian and Colombian isolates of Ramularia phaseolina.

	Ecuadorian	Colombian
Conidiophores	Hypophyllous, clustered, erect, more or less divergent, somewhat tapering toward the tip, simple or irregularly dichotomous, septa indistinct and at some distance from each other, 40-80μ x 3-7μ.	Identical, with exception that conidiophores grow along leaf trichomes to give appearance of fascicles or synnemata; a few, short, erect, single conidiophores scattered over leaf epidermis.
Conidia	Variable shape and size, mostly ellipsoid or ovoid, both ends bluntly rounded or becoming tapered toward the tip, finally sharply pointed or papillate at the tip so as to be lemon-shaped, straight or weakly curved, hyaline, 1-celled, larger ones with indistinct, centrally located cross wall, 7-18μ x 4-6μ.	Identical, with exception of tip acute or obtuse, base papillate at point of attachment, showing elongated lemon-shape, 0-septate common, 1-septate rare, 2-septate extremely rare, walls of 1- and 2-septate dividing the conidia into equal parts, 0-and most of 1-septate 8-13μ x 4-4.5μ, few 1-septate and all 2-septate 13-35μ x 4-4.5μ.

Complete studies of the effect of floury leaf spot on yields have not yet been made, but the disease is potentially serious. During some of the more humid growing seasons at altitudes of 1800 to 2200 meters, the disease ranked with, or higher than, anthracnose (Colletotrichum lindemuthianum (Sacc. & Magn.) Scrib.), gray blotch (Cercospora vanderysti P. Henn.), and angular leaf spot (Isariopsis griseola Sacc.) in prevalence and severity in commercial plantings. Moreover, it was considerably more important than rust (Uromyces phaseoli typica Arth.), powdery mildew (Erysiphe polygoni DC. ex Merat), and bacterial blight (Xanthomonas phaseoli (E. F. Smith) Dows.). The second growing season of 1957 was much drier and warmer than normal and the incidence of floury leaf spot was relatively low.

In the Cauca Valley, at an altitude of 1000 meters, where several thousand hectares of dry beans are grown twice each year, the disease is practically unknown. Similarly, on the Savannah of Bogota, at 2600 meters, floury leaf spot is rarely if ever seen. Temperature is probably the limiting factor in the regional distribution of Ramularia phaseolina, since the temperature differential between 1000 and 2600 meters is considerable in Colombia, whereas the annual precipitation from one region to another is fairly uniform.

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COLOMBIAN MINISTRY OF AGRICULTURE AND THE COLOMBIAN AGRICULTURAL PROGRAM OF THE ROCKEFELLER FOUNDATION

STUDIES ON THE ADDITIVE EFFECT OF STREPTOMYCIN SULFATE ON DIFFERENT SEED POTATO DISINFECTANTS FOR THE CONTROL OF BACTERIAL RING ROT[1]

Reiner Bonde and Barbara Johnson[2]

Abstract

Experiments were conducted to discover a seed potato disinfectant that will control the dissemination of ring rot during the process of cutting seed potatoes. Bichloride of mercury, acidified bichloride of mercury, and copper sulfate have been among the most effective materials for ring-rot control but they sometimes injured the seed potatoes of the Chippewa, Katahdin, Sebago and similar varieties. Streptomycin sulfate was the most effective antibiotic used in these experiments. Seed pieces contaminated with the bacteria were treated with different disinfectants with and without streptomycin sulfate in the dipping solutions. Most of the disinfectants gave significantly better disease control when combined with streptomycin sulfate than they gave without this antibiotic. Streptomycin sulfate appeared to have an additive or synergistic effect when in combination with the disinfectants used for the control of the ring-rot disease. Acti-dione was the only antibiotic used in these studies that materially injured the potato seed pieces and reduced the germination when planted in the field. The experiments make it appear that it may be practical to combine streptomycin sulfate with other disinfectants for treating seed potatoes for the control of the dissemination of the ring-rot disease.

INTRODUCTION

Field experiments have been conducted in Maine in an attempt to discover a desirable seed potato disinfectant for reducing the dissemination of bacterial ring rot, caused by Corynebacterium sepedonicum (Spieck. and Kotth.) Skapt and Burkh. Bichloride of mercury, acidified bichloride of mercury, and copper sulfate have been among the most effective for ring-rot control when used as dipping solutions for treating contaminated seed stocks (5, 6, 7).

These treating materials, however, have not always been effective in controlling the disease and sometimes have caused excessive seed piece injury, especially to the newer varieties such as Chippewa, Katahdin and Sebago. Studies conducted in Maine have shown that treating cut seed potatoes in solutions containing streptomycin or Agri-mycin 100 may greatly reduce the extent of bacterial seed piece decay and blackleg (1, 2, 4). Antibiotics also may increase the effectiveness of certain fungicides when used as sprays for the control of potato late blight (3).

In view of this information, experiments were conducted in an attempt to discover new disinfectants or combinations of disinfectants and antibiotics that can be used for reducing the spread of ring rot that occurs during the process of cutting and handling seed potatoes prior to being planted.

MATERIALS AND METHODS

Inoculations with pure cultures of the ring-rot organism have not consistently produced reliable results in the studies conducted in Maine. Therefore, diseased tubers grown for this purpose were used as the source of inoculum for contaminating the healthy seed potatoes.

The diseased portion of infected tubers were thoroughly macerated and added in varying amounts to sterilized rain water until a thick slurry resulted. Freshly-cut healthy Katahdin or Green Mountain seed potatoes were contaminated by dipping into the above-described infective material. Excessive moisture was drained from the contaminated seed pieces, then the

[1] This study was supported in part with Grant-in-Aid funds supplied by Chas. Pfizer Company, Brooklyn, New York.

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pieces were soaked for different periods of time in the various treating solutions being tested. The treated seed pieces were planted immediately in the field.

The plants that emerged from the treated seed pieces were examined for foliage symptoms of ring rot during the growing season. Tubers from plants that developed no ring-rot symptoms were cut and examined for the presence of the disease after harvest.

RESULTS

Preliminary Tests

A number of antibiotics were evaluated regarding their ability to control ring-rot infection when used to treat contaminated seed potatoes. Some of these did not appear to have value for reducing spread of the disease[3]. A number of other antibiotics, however, did have bacteriostatic properties that either delayed or reduced the amount of infection.

Polymyxin (100-200 ppm) delayed the appearance of visible disease symptoms but did not reduce the final number of infected plants at the end of the growing season. Aureomycin (chlortetracycline), Terramycin (oxytetraclycline)[4], Dihydrostreptomycin sulfate, and streptomycin sulfate (all at 100 ppm), in contrast, reduced the percentage of infected plants to 40, 35, 12 and 8, respectively, in comparison with 85 to 95 percent infection for the untreated controls.

For ring-rot control streptomycin sulfate was the most effective antibiotic of those included in this study. However, ring-rot control by streptomycin sulfate was not sufficient to warrant it being generally recommended in Maine for treating seed potatoes. An experiment, therefore, was conducted to determine whether better ring-rot control could be obtained by combining streptomycin sulfate with other disinfectants and chemicals.

Effect of Adding Streptomycin Sulfate to Disinfectants on Ring-rot Control

Samples of ring-rot contaminated seed potatoes were treated in solutions of the various antibiotics or disinfectants. The different disinfectants and concentrations of each disinfectant were made into two separate and similar solutions, one containing streptomycin sulfate 100 ppm and the other without. The contaminated seed pieces were treated for 5-minute periods and planted immediately in the field. Records were made comparing the number of diseased plants that developed from the seed potatoes that were treated in different solutions.

Table 1 summarizes the information derived from this experiment. All of the chemicals with the exception of soluble Terramycin at 100 ppm reduced ring-rot infection in comparison with the untreated controls. Acti-dione (cycloheximide) and Phytomycin (streptomycin nitrate) were the most effective for ring-rot control, followed by bichloride of mercury and Semesan Bel.

Acti-dione, although very effective in controlling ring rot, injured the seed potatoes and caused from 5 to 10 percent reduction in emergence at both concentrations. None of the other treatments reduced the number of plants that emerged.

It is significant that all of the disinfecting solutions with the exception of Terramycin at 500 ppm were more effective for the control of ring rot when in combination with streptomycin sulfate. It thus appears from the results of this experiment that streptomycin sulfate may have an additive effect on ring-rot control when combined with a number of disinfectants and other chemicals. Other experiments conducted in Maine have shown that the control of potato late blight was increased by the addition of streptomycin sulfate to the fungicidal spray mixtures (3).

It is important that the combination treatments did not appear to injure the seed potatoes and, with the exception of Acti-dione, did not reduce germination. The experiment indicates that it may be practical for farmers to use a combination of streptomycin sulfate and a suitable disinfectant for treating seed potatoes for the control of ring rot and possibly some other diseases that are disseminated during the cutting operation.

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[3] Bacitracin, Candicidin, Neomycin, Penicillin, Rimocidin and Streptothricin did not materially reduce ring-rot infection when used as a dipping solution at 100 ppm.

[4] Terramycin "soluble" has generally been more effective in reducing ring-rot infection than the regular Terramycin supplied by Chas. Pfizer Company.

Table 1. Percentage ring-rot infection from inoculated potato seed pieces treated with different disinfectants with and without streptomycin sulfate in treating solution.

Treating material	Concentration	Percentage of plants infected[a]	
		With streptomycin	Without streptomycin
Acti-dione (cycloheximide)[b]	50 ppm	0.0	6.0
	100 ppm	0.0	0.0
Bichloride of mercury	1-500	8.0	36.0
	1-1000	12.0	24.0
Captan N-trichloromethylmercapto-4-cyclohexene 1:2 - dicarboximide Triozine	2 lbs/100	6.0	50.0
	4 lbs/100	4.0	50.0
Pfizer 2601-109 Terramycin and Polymyxin	50 ppm 25 ppm	20.0	52.0
Terramycin and Polymyxin	100 ppm 50 ppm	6.0	54.0
Phix (Phenyl mercuric acetate)	2 oz/100	2.0	50.0
	4 oz/100	4.0	50.0
Phytomycin (Streptomycin nitrate)	100 ppm	0.0	10.0
	200 ppm	0.0	4.0
Semesan Bel Hydroxymercurinitrophenol, 12% Hydroxymercurichlorphenol, 2%	0.5 lbs/7.5 gals	8.2	32.0
Hydroxymercurinitrophenol, 12% Hydroxymercurichlorphenol, 2%	1.0 lbs/7.5 gals	14.0	26.0
Terramycin (soluble) (Oxytetracycline)	100 ppm	3.6	96.0
	200 ppm	40.0	34.0
	500 ppm	40.0	34.0
Streptomycin sulfate	50 ppm	30.0	--
	100 ppm	17.0	--
Mean		13.0	34.6
Untreated controls			84-100
LSD 1%		16.67	

[a] Based on 100 inoculated seed pieces for each treatment.
[b] Reduced the seed piece germination from 5 to 10 percent at both concentrations.

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MAINE AGRICULTURAL EXPERIMENT STATION, ORONO, MAINE

INFLUENCE OF FUNGICIDES, CALCIUM SALTS, GROWTH REGULATORS AND ANTIBIOTICS ON COTTON SEEDLING DISEASE WHEN MIXED WITH THE COVERING SOIL

C. D. Ranney and L. S. Bird[1]

Summary

Fungicides, calcium salts, growth regulators and antibiotics mixed with the covering soil during planting were tested as control measures to reduce cotton seedling disease losses in Texas in 1957.

Some of the fungicides, as well as other materials, were effective in controlling the disease.

Data from tests at several locations, on different soil types and at various soil pH levels, indicate that several of the fungicides do not give the same response over a relatively wide pH range. One combination of fungicides gave a uniform response over the range encountered in these tests.

The practice of mixing fungicides with the covering soil at planting for controlling the cotton seedling disease complex has been tested in Texas since 1953 (1, 2, 4). By testing materials at different rates, and by combining materials which have shown indications of reducing seedling losses, an increasing degree of control has been noted each year. The results of tests at several locations in 1957 indicated that the practice of mixing fungicides in the covering soil is a practical, effective and economical means of reducing seedling disease (2). Recommendations as to materials, method and rate of application have been released for the 1958 season (2, 8). As test data have been collected and analyzed, several environmental factors affecting the response of the fungicides have been noted. Temperature has a decided influence (7) on the response and effectiveness of different materials. Results of the 1957 tests in Table 1 point out the association of soil pH and variation in response to the fungicidal materials. Of the materials tested only the mixture of 1 1/2 pounds 50% captan, 2 pounds 65% zineb and 1 1/2 pounds 75% PCNB was effective in maintaining higher plant populations per acre over the entire range of soil pH levels encountered in these tests. The application of 4 quarts of nabam was effective on soil with a pH of 7.0 or lower, but above a pH of 7.6 its effectiveness was markedly reduced. Other unpublished data indicate that a pH level of 7.3 is the critical point in this response. A mixture of 2 pounds 50% captan, 2 pounds 75% PCNB and 1/4 quart of Ceresan 200 maintained good stands in soils with a high pH, but was not as effective at lower pH levels. With this combination the critical point is in the range of 7.6 to 8.0; further testing will be required to determine the exact level.

1957 PRELIMINARY TESTS

Several preliminary tests were planted on Lufkin fine sandy loam soil at College Station, Texas. All materials were applied as sprays at the rate of 10.5 gallons per acre. Three cone type nozzles were used, two placed so that they were spraying the seed furrow and the soil immediately ahead of each covering device, the third placed so that it was spraying the soil as it was rolled into the seed furrow (Figure 1).

The same tractor, planting and sprayer equipment, and seed supply (acid delinted, Ceresan M-treated Deltapine 15 seed, with 92 percent germination) were used for each test. Plots were 50 feet in length. Stand counts were made in the central 26.2 feet of each row 21 to 24 days after emergence of the first seedlings. The test design was a randomized complete block with six replications.

The results of the first test are presented in Table 2. Maneb and thiram, both alone and in combination with Ceresan 200, were effective in reducing losses due to the seedling disease

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Table 1. Results of fungicides mixed with the covering soil for controlling the seedling disease complex of cotton at several Texas locations, 1957.

Material and rate per acre	Average final stand as percent of control						
	Pear-sall	Lobo 1	Lobo 2	Lobo 3	College Station	Greenville	Average of six tests
Soil pH	7.6	8.0	8.0	8.3	4.8	7.0	
Captan (1 1/2 lbs) + zineb (2 lbs) + PCNB (1 1/2 lbs)	159	146	143	200	176	450	168
Captan (2 lbs) + PCNB (2 lbs) + Ceresan 200 (1/4 qt)	107	148	149	190	123	233	145
Nabam (4 qts)	104	78	120	122	139	433	116
Check	100	100	100	100	100	100	100

Table 2. Preliminary test I, spring 1957, of materials mixed with the covering soil to control cotton seedling disease.

Material	Rate per acre	Average Stand[a]
65% Thiram + Ceresan 200	3 lbs + 1/2 qt	86.3**
70% Maneb + Ceresan 200	3 lbs + 1/4 qt	83.8**
70% Maneb	5 lbs	83.0**
22% Nabam + Ceresan 200	3 qts + 1/2 qt	81.0**
70% Maneb + Ceresan 200	3 lbs + 1/2 qt	79.8**
65% Thiram	5 lbs	70.8**
65% Thiram + Ceresan 200	3 lbs + 1/4 qt	69.7**
22% Nabam + Ceresan 200	3 qts + 1/4 qt	63.5*
Ceresan 200	1/2 qt	43.5
Check	--	39.2
Ceresan 200	1 qt	19.0*
Ceresan 200	3/4 qt	2.5**

[a] Average final stand in plants per 26.2 feet of row, 40 inch spacing.

** Significantly different from check at .01 level of probability by Duncan's test.

* Significantly different from check at .05 level of probability by Duncan's test.

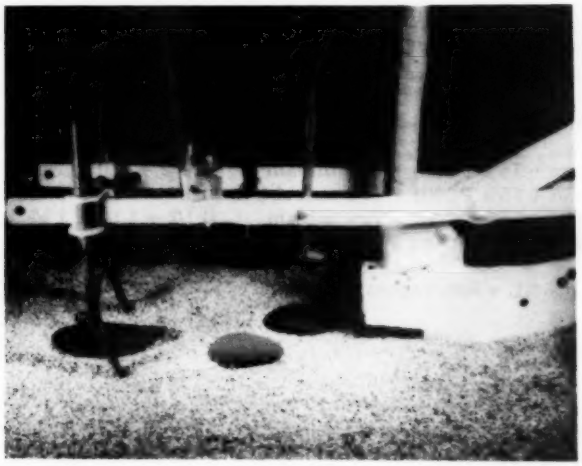

FIGURE 1. Nozzle arrangement used in applying materials to the covering soil.

complex. These data indicate that Ceresan 200 is less phytotoxic in combination with other fungicides. Ceresan 200 alone was ineffective at the 1/2 quart rate and phytotoxic at higher rates. In the latter instance, plants were both stunted and necrotic, with significantly reduced populations.

Table 3 shows the results of the second preliminary test. Several fungicides and two inorganic salts were tested. The nitrate salts were included to study the effect, if any, of a readily available source of nitrogen and calcium. Presley and Leonard (6) reported a beneficial effect of calcium on the development and health of cotton seedlings under laboratory conditions. Eaton and Ergle (3) have shown that the calcium content of the cottonseed is relatively low, especially for a macro element. Although it is not indicated in the table, the calcium nitrate treatment is significantly better than the sodium nitrate treatment at the .01 level of probability by Duncan's test. These data indicate that the additional calcium in some way contributes to a more healthy or resistant plant. Thiram and maneb, in combination with captan and PCNB, also promoted significantly better stands, as did the PCNB and Omadine 1562 treatment.

In the past few years various antibiotics have proven to be valuable in controlling plant diseases (5). Results obtained from applying several of these materials as in-the-furrow treatments are presented in Table 4. Of the materials and rates tested only the low rate of Actidione and ferrous sulfate was effective in preventing reduced stands. Typical symptoms of phytotoxicity were not noted at any of the rates tested. The data indicate, however, a trend toward reduced stands with increasing rates of the antibiotics.

Various growth regulators were applied as in-the-furrow treatments to see whether they induce more rapid germination and emergence or increased tolerance of the plant to seedling disease. Of the materials tested only the potassium salt of gibberellic acid gave stands significantly better than the check (Table 5). No influence on the rate of emergence was noted for any treatment. Initially the gibberellic-acid-treated plants appeared to be slightly taller than the other plants, but when the test was evaluated, 21 days after planting there was no difference in plant height.

Several tests were planted in the early fall to evaluate further materials which appeared promising in the spring tests as well as new materials. Environmental conditions for development of the seedling disease complex were good, with 7 inches of rainfall occurring and cool weather prevailing during the test period. Many materials which gave good results in the spring were included in the fall test. The data are presented in Table 6. Although environmental conditions seemed favorable to seedling disease, the high final stand in the check indicated that disease incidence was much lower than in the spring, or in the other fall tests. Under these conditions none of the materials applied produced stands significantly better than the check, and one treatment, which was very similar to one of the better spring treatments, gave

Table 3. Preliminary test II, spring 1957, of materials mixed with the covering soil to control cotton seedling disease.

Material	Rate per acre	Average stand[a]
$Ca(NO_3)_2$	10 lbs	110**
50% Captan + 75% PCNB + 65% thiram	2 + 2 + 2 lbs	100.8**
50% Captan + 75% PCNB + 70% maneb	1 1/2 + 1 1/2 + 2 lbs	98.0**
50% Captan + 75% PCNB + 65% thiram	1 1/2 + 1 1/2 + 1 1/2 lbs	96.0*
50% Omadine 1562 + 75% PCNB	1 1/2 + 3 lbs	91.8*
$NaNO_3$	10 lbs	78.8
50% Phygon XL + 50% captan	1 1/2 + 3 lbs	74.5
Check	----	67.3
Carbon + carbide 11478	3 lbs	58.8
Penn salt TD-40	2 lbs	53.0
Carbon + carbide 11478	5 lbs	33.5**
Penn salt TD-40	4 lbs	33.3**

a Average final stand in plants per 26.2 feet of row, 40 inch spacing.
** Significantly different from check at .01 level of probability by Duncan's test.
* Significantly different from check at .05 level of probability by Duncan's test.

Table 4. Preliminary test III, spring 1957, of materials mixed with the covering soil to control cotton seedling disease.

Material	Rate per acre	Average stand[a]
5% Actidione + $FeSO_4$	2 oz + 2.5 oz	105.3[b]
Agri-mycin	1 lb.	81.0
Agri-mycin	3 lbs.	74.7
5% Acti-dione + $FeSO_4$	3 oz + 3.8 oz	71.3
Check	----	69.5
5% Acti-dione	2 oz	69.2
5% Acti-dione	3 oz	68.3
5% Acti-dione + 75% PCNB	3 oz + 12 oz	65.7
Agri-mycin	5 lbs	63.2
5% Acti-dione + 75% PCNB	2 oz + 8 oz	62.3

a Average final stand in plants per 26.2 feet of row, 40 inch spacing.
b This treatment differs significantly from check at .01 level of probability by Duncan's test. None of the other treatments differ significantly from the check.

Table 5. Growth regulator test, spring 1957, materials mixed in the covering soil to control cotton seedling disease.

Material[a]	Average stand[b]
Gibberellic acid (K salt)	86.50[c]
O-Chlorophenoxyacetic acid	75.67
Indolebutyric acid	75.50
Indole-3-acetic acid	75.33
P-Chlorophenoxyacetic acid	74.17
Ethyl-3-Indoleacetate	70.50
Methyl-1-naphthaleneacetic acid	67.50
Maleic acid hydrazide	67.00
B-(2 Furyl) acrylic acid	66.33
Check	65.50
3-Indolepropionic acid	60.17
B-Naphthoxyacetic acid	60.00
A-Naphthaleneacetamide	55.67
Naphthaleneacetic acid	55.50

a All materials applied in a 5 ppm aqueous solution at the rate of 10.5 gallons per acre.

b Average final stand in plants per 26.2 feet of row, 40 inch spacing.

c This treatment differs significantly from check at .05 level of probability by Duncan's test. None of the other treatments differ significantly from the check.

Table 6. Preliminary test IV, fall 1957, of materials mixed with the covering soil to control cotton seedling disease.

Material	Rate per acre	Average stand[a]
22% Nabam + Ceresan 200	3 qts + 1/2 qt	123.8
70% Maneb	5 lbs	119.8
70% Maneb + Ceresan 200	3 lbs + 1/4 qt	116.7
65% Thiram + Ceresan 200	3 lbs + 1/2 qt	113.8
70% Maneb + Ceresan 200	3 lbs + 1/2 qt	110.2
Check	----	107.0
70% Maneb + 65% thiram	2 + 2 lbs	105.0
50% Captan + 75% PCNB + 65% thiram	2 + 2 + 2 lbs	97.3
50% Captan + 75% PCNB + 70% maneb	1 1/2 + 1 1/2 + 2 lbs	94.0
50% Captan + 75% PCNB + 65% thiram	1 1/2 + 1 1/2 + 2 lbs	88.0*

a Average final stand in plants per 26.2 feet of row, 40 inch spacing.

* Significantly different from check at .01 level of probability by Duncan's test.

Table 7. Preliminary test V, fall 1957, of materials mixed with the covering soil to control cotton seedling disease.

Material	Rate per acre	Average stand[a]
22% Nabam + $Ca(NO_3)_2$	4 qts + 10 lbs	110.3**
$CaCl_2$	10 lbs	96.5*
75% PCNB + 50% captan + $Ca(NO_3)_2$	2 + 2 + 10 lbs	96.2*
Shive's solution	10 normal	92.3
$Ca(NO_3)_2$	10 lbs	85.2
75% PCNB + $Ca(NO_3)_2$	3 + 10 lbs	78.7
Shive's solution + gibberellic acid	10 normal + 10 ppm	78.2
Check	----	77.7

a Average final stand in plants per 26.2 feet of row, 40 inch spacing.
** Significantly different from check at .01 level of probability by Duncan's test.
* Significantly different from check at .05 level of probability by Duncan's test.

Table 8. Preliminary test VI, fall 1957, of materials mixed with the covering soil to control cotton seedling disease.

Material	Rate per acre	Average stand[a]
Acti-dione + $FeSO_4$	2.0 oz + 2.5 oz	99.8**
Panogen 15	1 1/2 qts	91.0*
Panogen 15 + 65% zineb	1 1/2 qts + 2 lbs	84.3
Panogen 15 + 75% PCNB + 65% zineb	1 1/2 qts + 1 + 1 lb	84.2
Panogen 15 + 75% PCNB	1 1/2 qts + 2 lbs	83.8
Panogen 15 + 50% captan	1 1/2 qts + 2 lbs	79.8
Panogen 15 + 75% PCNB + 50% captan	1 1/2 qts + 1 + 1 lb	76.2
Check	----	68.5

a Average final stand in plants per 26.2 feet of row, 40 inch spacing.
** Significantly different from check at .01 level of probability by Duncan's test.
* Significantly different from check at .05 level of probability by Duncan's test.

a final stand that was significantly lower than the control.

The check data, presented in Table 7, indicate that the disease incidence in this test was higher than that of the spring tests. Again, the influence of addition of calcium on the development of healthy seedlings is apparent, and calcium is effective, both alone and in combination with fungicidal materials. Complete nutrient solutions, such as Shive's solution, at the rate applied, apparently are not as effective as the calcium salts alone. The presence of gibberellic acid at 10 ppm did not stimulate or promote a better stand in combination with the complete nutrient solution.

In preliminary test VI, the data of which are presented in Table 8, the Acti-dione-ferrous sulfate treatment which appeared promising in the spring again gave stands significantly better than the check. The mercurial material, Panogen 15, at the rate of 1 1/2 quarts per acre also gave stands significantly better than the check.

DISCUSSION AND CONCLUSIONS

These results show that the effectiveness of some fungicides against the cotton seedling disease complex is modified by soil pH or conditions associated with soil pH. A mixture of 1 1/2 pounds captan, 2 pounds zineb and 1 1/2 pounds PCNB will give a very similar, if not uniform, response over a relatively wide range of both soil temperature (7) and pH. By using this combination of fungicides as a standard in tests at different locations a more accurate estimate of fungicide effectiveness on different soil types, moisture conditions and microbial populations could be made.

The Lufkin fine sandy loam soil on which these tests were conducted has a calcium content of 350 ppm expressed as CaO, and a pH of 4.8. Under these conditions, the beneficial effect of adding calcium, noted in vitro by Presley and Leonard (6), appeared to be related to reduced seedling losses in the field. Testing under a wider range of soil conditions is necessary to determine the value of readily available calcium as a factor in reducing seedling losses.

The fall tests, conducted under conditions usually associated with a high incidence of seedling disease, emphasize the ever present problem in selecting a material for application as a seedling disease control measure. That is, under excellent conditions for seed germination and seedling development the materials applied for disease control must not, either by physiological modification of the seedling or by changing the soil microflora, cause reduced stands.

The results indicate that maneb, thiram, Omadine 1562, Acti-dione, Ceresan 200, Panogen 15, calcium chloride, calcium nitrate and gibberellic acid, either alone or in combination with other materials, are effective in reducing losses from the seedling disease complex in cotton.

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ROOT-KNOT NEMATODES, A SERIOUS PROBLEM OF KENAF IN FLORIDA[1]

T. E. Summers and C. C. Seale[2]

Abstract

The nematodes Meloidogyne incognita and M. incognita acrita damage kenaf by killing small seedlings, causing stunting and premature death of older plants and reducing fiber yield. The fiber yield of kenaf grown in infested soil was 1202 pounds per acre as compared to 2327 pounds per acre in fumigated soil.

Observations that certain root-knot nematodes attack kenaf, Hibiscus cannabinus L., have been reported from Florida (3, 4, 5, 6). Also, a nematode-root disease complex has been reported to be a serious problem of kenaf fiber production in Java (2) and Cuba (1). It is interesting that in Florida during the years 1953-56 the vascular wilt fusaria have not been as important contributors to the nematode-fungus disease syndrome as other fungi. Several fungi which cause necrosis of the roots and a decay of the basal portion of the stem are fusaria of the Martiella group, Sclerotium bataticola, S. rolfsii, Phytophthora spp. and Pythium spp. The exact extent of damage caused by these fungi, independently, in combination with each other, and in combination with nematodes, is under investigation. This report is concerned with the degree of severity, including the measured effect on dry fiber yield, to which kenaf is affected by root-knot nematodes.

DAMAGE TO KENAF GROWTH AND FIBER YIELD

The degree of nematode infestation of the soil in which kenaf is planted naturally exerts considerable influence upon the severity of damage sustained by the crop. Since most cultivated soils in south Florida are infested by either Meloidogyne incognita and/or M. incognita acrita, the probability of growing kenaf in nematode-free soil is not great.

Effect on Seedlings

When kenaf was planted in soil which had been planted to kenaf or susceptible vegetables the previous season, severe damage in the seedling stage was experienced. In some fields the small seedlings were attacked, stunted and even killed (Figure 1). Severe attacks, such as shown in Figure 1, led to such a drastic reduction in stand that the affected areas became overgrown with noxious weeds and were lost for either fiber or seed production.

Effect on Older Plants

In many instances when plants were not killed after having been attacked as seedlings, they remained stunted and made poor growth throughout the season. Other plants showed little or no apparent ill effect until they approached maturity, when they ceased growing prematurely, wilted and died before reaching harvestable age. Such premature death of plants is particularly damaging under low moisture conditions and presents a serious problem in yield loss and reduced fiber quality. Since the stalks in affected areas become dried and may fall over, a problem in harvesting may result from the tangling of stalks.

If factors such as soil moisture and fertility are optimum, kenaf may show little or no apparent damage from relatively heavy nematode attack, though data from control experiments have demonstrated that reduction in fiber yield results even under favorable growth conditions.

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[1]The research work on which this report is based was conducted cooperatively by the Crops Research Division and the Agricultural Engineering Research Division, Agricultural Research Service, United States Department of Agriculture, and the Everglades Experiment Station of the University of Florida Agricultural Experiment Station.

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Florida Agricultural Experiment Station Journal Series, No. 742.

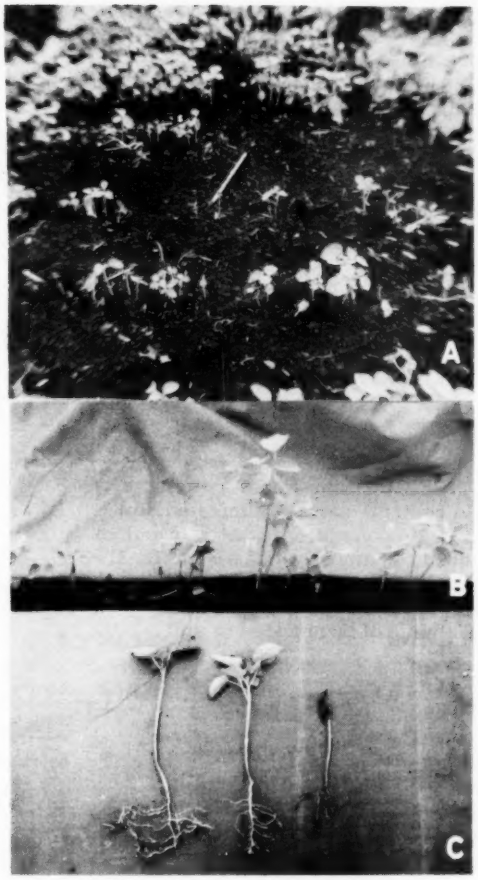

FIGURE 1. Kenaf seedlings attacked by root-knot nematodes. A -- Area in field showing stunting and death of seedlings. Notice dead plants at point of pencil. B -- Portion of area shown in A above. C -- Roots of three plants shown in B above, plant on right having been killed.

Dry Fiber Yield

Although observations had established kenaf as subject to attack by root-knot nematodes, no definite measure of fiber loss from these attacks was available. To determine the quantitative extent of damage to kenaf by the nematodes most prevalent in South Florida and, consequently, arrive at a valid estimate of the increase in fiber yield to be expected from effective control measures, an experiment using the fumigant chloropicrin was conducted on Delray fine sand near Lake Worth, Florida.

PROCEDURE

To circumvent the variability usually associated with nematode infestations occurring naturally in field soil, both naturally infested soil and naturally infested soil to which had been added severely galled kenaf roots were utilized. The treated plots were fumigated with chloropicrin[3] at 40 gallons per acre. The fumigant was applied to the soil 14 days prior to planting. The plots were fertilized with 700 pounds per acre of an 8-8-16 mixed fertilizer applied in the drill prior to planting. This experiment consisted of the following treatments replicated four times in a randomized block design.

[3]Furnished by the Wilson Spray and Supply Co., West Palm Beach, Florida.

A. No control -- naturally infested soil.
B. No control -- root-knot inoculum added to naturally infested soil.
C. Fumigated -- naturally infested soil.
D. Fumigated -- root-knot inoculum added to naturally infested soil prior to fumigation.

Kenaf seed were planted at 30 pounds per acre on April 30, 1953 in rows 7 inches apart. On August 10 samples from 32 square feet were harvested from each plot. Green weights of the above ground portion of the plants were recorded and to determine dry fiber yield the fiber was extracted by retting. Samples of the stalks from one replication are shown in Figure 2.

FIGURE 2. Kenaf from plots. A -- No control, naturally infested soil. B -- No control, root-knot inoculum added to naturally infested soil. C -- Fumigated, naturally infested soil. D -- Fumigated, after root-knot inoculum had been added to soil.

RESULTS AND DISCUSSION

The per acre yields of dry fiber based on the plot yields for the different treatments were: (A) no control, naturally infested soil, 1239 pounds per acre; (B) no control, root-knot inoculum added to soil 1266 pounds per acre; (C) fumigated, naturally infested soil, 2232 pounds per acre; (D) fumigated, root-knot inoculum added prior to fumigation 2423 pounds per acre. Table 1 shows the green weight of plant material and dry fiber per acre yield for each of the four treatments.

The data in Table 1 indicate that the effective control of the root-knot attacking nematodes may result in a substantial increase in fiber yield. The increase was highly significant between the fumigated and non-fumigated plots for both naturally infested field soil and artificially infested soils. Average yield for the non-fumigated plots was 1202 pounds dry fiber per acre, as compared with 2327 pounds per acre for the fumigated plots. While a part of the yield increase may have resulted from the fumigant's action on other pathogens, a large measure of the increase must be attributed to control of root-knot nematodes.

Fumigation of muck soil at the Everglades Experiment Station, Belle Glade, has resulted in comparable increases in fiber yields over yields from untreated infested organic soil.

As one phase of attack on the nematode problem, newer and less expensive nematacides are being tested.

Table 1. Green weight and dry fiber yield in pounds per acre for kenaf grown near Lake Worth, Florida. Fumigated plots treated with chloropicrin 14 days prior to planting.

Treatments	Yield - Pounds Per Acre	
	Green Weight	Dry Fiber Weight
A. No control - natural infestation	25,864	1239
B. No control - inoculum added	24,775	1266
C. Fumigated - natural infestation	43,696	2232
D. Fumigated - inoculum added prior to fumigating	47,235	2423
LSD (.05)	6,485	308
LSD (.01)	9,317	442
C. V. percent	11.5	11.0

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RESISTANCE OF HIBISCUS EETVELDIANUS TO ROOT-KNOT NEMATODES AND THE POSSIBILITIES OF ITS USE AS A SOURCE OF RESISTANCE IN KENAF, HIBISCUS CANNABINUS L.[1]

J. B. Pate, T. E. Summers and M. Y. Menzel[2]

Summary

Hibiscus eetveldianus has been found resistant and kenaf, H. cannabinus, susceptible to root-knot nematodes in field tests in south Florida. Sterile F_1 hybrids of these two species have been treated with colchicine to give fertile amphiploids which approach, H. eetveldianus in resistance. However, these amphiploids lack some of the desirable plant type characteristics of kenaf. Attempts at backcrossing to kenaf have failed so far, and cytological studies are now underway to determine the best procedure for combining the root-knot resistance of H. eetveldianus and the plant type of kenaf in a single fertile line.

Kenaf, Hibiscus cannabinus, is extremely susceptible to root-knot nematodes, and breeding for resistance has been an important consideration in the fiber program in south Florida. All types of kenaf tested have been susceptible, although certain selections have exhibited some apparent tolerance (2). One approach to the problem has been to cross a desirable fiber type kenaf with the related non-fiber species, H. eetveldianus, which is highly resistant to the nematodes Meloidogyne incognita and M. incognita acrita (1). This report concerns the resistance of this related species and studies to date of attempts to transfer this resistance to kenaf.

H. eetveldianus, a common ornamental in south Florida, and various selections of kenaf have been tested over a number of years in root-knot nematode infested sandy soils near Lake Worth and peat soils near Belle Glade. The resistance of eetveldianus has always been outstanding, with galls from nematodes being few in number and small in size. In comparison, kenaf has been severely galled.

At the beginning of studies in the transfer of the resistance of eetveldianus to kenaf reciprocal crosses between the two species were made. F_1 hybrids were obtained in both crosses. All F_1 plants observed have been almost completely sterile. An occasional seed is produced, but plants from these have been similar to the F_1 in sterility. All attempts to backcross to both kenaf and eetveldianus have failed.

The sterility of the hybrids led to efforts to double the chromosome number of the F_1 through the use of colchicine. Several hundred seed were produced on F_1 plants treated with colchicine in 1954. It was assumed that doubling of the chromosome number occurred to give an amphiploid.

The seed produced following colchicine treatment were planted in 1955. In this C_2 population open-pollinated seed were harvested from individual plants. In 1956 one hundred C_3 progenies and the parental species were tested on severely infested sandy soils near Lake Worth for reaction to root-knot nematodes. Root systems of the plants were rated on a scale of 0 for no galls to 5 for severe galling. Ten plants per plot were examined. The resistance of C_3 progenies, with mean ratings of 1 and below, approached that of eetveldianus. On the other hand, severe galling, with mean ratings of 3.5 and above, was observed in check plots of kenaf. Representative root systems of kenaf, eetveldianus and the amphiploid are shown in Figure 1.

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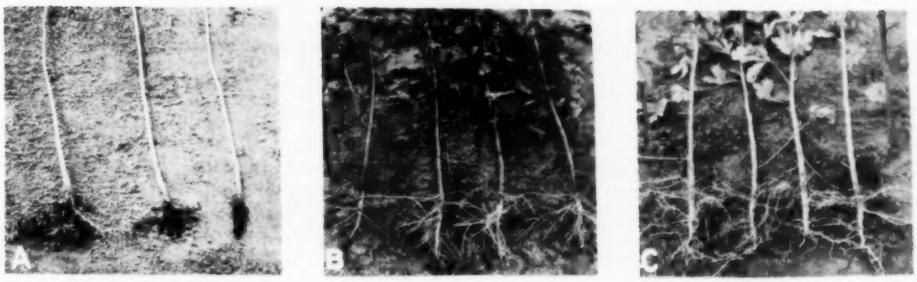

FIGURE 1. Representative root systems. A -- Kenaf, B -- H. eetveldianus. C -- Amphiploid of the two species. Note the resistance to root-knot nematodes in eetveldianus and the amphiploid in comparison with the susceptibility of kenaf.

The excellent resistance of the amphiploid progenies is considered very encouraging. However, these materials are not particularly desirable types of plants for fiber. Furthermore, there is very little segregation within the amphiploid for plant type. These facts necessitate adding more kenaf characters by backcrossing, if possible. No seed were set in numerous reciprocal crosses of several of the C_3 progenies with both kenaf and eetveldianus.

Preliminary cytological investigations have been made recently to help explain results obtained thus far and to point a way to proceed in the future. It has been found that kenaf, eetveldianus, the F_1 of these two species and the C_3 generation of the double hybrid have 2n chromosome numbers of 36, 72, 54 and approximately 108, respectively. Thus, the sterile F_1 is triploid, and the amphiploidy of the fertile material resulting from colchicine treatment has been confirmed cytologically.

The best procedure in a breeding program designed to incorporate the root-knot nematode resistance of eetveldianus and the plant type of kenaf into a single fertile line will depend upon the genome relationships of the two species. Studies designed to give this information are now underway. In addition, selection within the amphiploid and attempts at backcrossing to kenaf are continuing.

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CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE FLORIDA AGRICULTURAL EXPERIMENT STATIONS, EVERGLADES EXPERIMENT STATION

PLANT PARASITIC NEMATODES ASSOCIATED WITH SOYBEANS IN ILLINOIS[1]

Virginia R. Ferris and R. L. Bernard[2]

Summary

Plant parasitic genera of nematodes found to be widely distributed in Illinois soybean fields included Pratylenchus, Paratylenchus, Helicotylenchus, and Tylenchorhynchus. Comparisons among fields in rotation indicated that the higher counts of Pratylenchus and Helicotylenchus in the soil were often associated with corn, whereas the higher counts of Paratylenchus were associated with soybean culture.

Roots and soil were taken from a number of soybean fields over the State of Illinois during the summer of 1957 for a preliminary investigation as to the kinds of plant parasitic nematodes present. Four genera of plant parasitic nematodes appeared to be widely distributed in Illinois and often were present in large numbers in soil and roots. These were Pratylenchus Filipjev, 1934, Paratylenchus Micoletzky, 1922, Helicotylenchus Steiner, 1945, and Tylenchorhynchus Cobb, 1913. Large numbers of Tylenchus Bastian, 1865, were also found in nearly all samples. As a result of these observations it was decided to undertake a quantitative survey of the nematode populations of representative areas of the State.

MATERIALS AND METHODS

Samples of soil were taken in October 1957 from the 11 soybean fields used for soybean varietal trials. These locations range from near Shabbona in northern Illinois, at a latitude of 42° and with an average frost-free period of 152 days, to near Miller City in the southern tip of the State, at a latitude of 37° and with a 213-day growing season.

In addition, a number of different fields in soybeans and in corn preceding soybeans in various rotations were sampled on the University of Illinois Agronomy Farm near Urbana in Champaign County to investigate local variability and the effect of crop species. One plot in the Morrow Plots in which corn had been grown continuously for 76 years and a wooded area never under cultivation were also sampled.

Cores of soil 8 inches long were taken with a 3/4 inch diameter soil sampling tube. Each sample included 20 cores taken at intervals of approximately 50 feet in a rectangular 4 x 5 pattern. The soybean fields were sampled when the plants were nearly ripe, ripe, or recently harvested. The cores were taken in the row. In 8 of the fields listed in Table 1 the area sampled contained a number of different strains of soybeans, but at the Miller City location the field sampled contained only the Ogden variety, and at Newton and Oblong the Adams variety was grown. The samples were taken from the corn fields in a similar manner. The corn was nearly ripe in the fields in rotation with soybeans. In the Morrow Plots sampling was done subsequent to plowing.

The soil samples were stored at 40° F in plastic bags and were processed during the winter of 1957. A uniform method of washing through screens and resuspending the residues in a Baerman extraction funnel was used for a 1-pint subsample taken from each well-mixed sample. The nematodes were drawn from the funnel after 24 hours and again after 48 hours. The nematodes from a given subsample were combined, relaxed in a water bath at 125° F for 5

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Table 1. Nematodes per pint of soil from soybean fields in Illinois, fall, 1957.

Location[a]	Previous crop	Praty-lenchus	Helico-tylenchus	Para-tylenchus	Tylencho-rhynchus
Dekalb, Shabbona[c]	corn	few[b]	1126	56	0
Livingston, Dwight[d]	corn	10	296	4	0
Macoupin, Girard[e]	corn	20	7	33	0
Greene, Carrollton[e]	soybeans	7	0	798	8540
Crawford, Oblong[f]	corn	177	177	40	39
Jasper, Newton[f]	wheat	10	0	255	30
Effingham, Edgewood[f]	soybeans	7	0	248	0
Saline, Eldorado[g]	corn	170	52	0	13
Jackson, Carbondale[f]	sorghum	98	0	17	0
Pulaski, Ullin[h]	corn	59	952	285	383
Alexander, Miller City[i]	corn	40	137	few	176

[a] County and nearest town.
[b] The word "few" indicates that members of the genus were observed in the collection, although they were not in sufficient numbers to appear in the aliquots counted.
[c] Soil type: Permeable black prairie silt loam.
[d] Soil type: Slowly permeable black prairie silt loam.
[e] Soil type: Slowly permeable light-colored silt loam.
[f] Soil type: Gray prairie silt loam with heavy clay subsoil.
[g] Soil type: Bottomland silty clay loam.
[h] Soil type: Terrace silt loam.
[i] Soil type: Bottomland fine sandy loam.

minutes, and fixed and stored in 5% formalin. Two aliquots from each subsample were counted.

Root samples were obtained in the early fall from several of the fields. The samples, consisting of the washed smaller roots of from three to six root systems, were incubated according to the method of Young[3].

RESULTS

Variations in nematode numbers between the two aliquots from each sample were analyzed by means of a chi-square test, and were found to be non-significant at the 5 percent level in

[3] Young, T. W. 1954. An incubation method for collecting migratory endoparasitic nematodes. Plant Dis. Reptr. 38: 794-795.

Table 2. Nematodes per pint of soil from fields on the Agronomy Farm[a] and Brownfield Woods[b], Urbana, Illinois, 1957.

Location	Crop history 1954	1955	1956	Praty-lenchus	Helico-tylenchus	Para-tylenchus	Tylencho-rhynchus
Fields in soybeans 1957							
Field 1101	soybeans	soybeans	soybeans	11	206	1437	few
Field 1201	oats	wheat	corn	206	674	294	59
Field M1N	clover	corn	corn	20	1432	30	20
Field M2S	wheat	corn	corn	13	209	7	0
Field M8W	soybeans	corn	corn	59	265	few	0
Field in corn 1957							
Morrow Plots		corn since 1876		372	1860	0	461
Field 1202	soybeans	oats	wheat	118	2823	50	520
Field M2N	clover mixture	clover mixture	corn	319	1233	665	20
Field M3S	oats	wheat	corn	666	304	20	59
Wooded Area							
Brownfield Woods		Never cultivated		0	577	0	275

[a] Soil type: Black prairie silt loam.
[b] Soil type: Light-colored silt loam.

Table 3. Nematodes recovered from soybean roots, fall, 1957.

Location	Variety	Pratylenchus	Paratylenchus	Meloidogyne
Urbana, Field 1101	mixed	+	+	0
Urbana, Field M2S	Clark	+	0	0
Urbana, Field M8W	T 175	+	0	0
Shabbona	Lincoln	+	+	0
Carrollton	Lee & Ogden	+	+	0
Ullin	Lee	+	+	0
Miller City	Perry	+	+	+

all samples but one, which was non-significant at the 1 percent level. Averages of the calculated numbers of nematodes per pint of soil are given in Tables 1 and 2. Only nematodes belonging to genera thought to be plant parasitic and present in appreciable numbers are included in the tables. Of other genera encountered, Tylenchus spp. were present in large numbers and species of Psilenchus de Man, 1921, and Hoplolaimus Daday, 1905, in small numbers. Table 3 gives the locations from which root samples were taken and the kinds of nematodes recovered.

DISCUSSION

Although the figures for the numbers of nematodes present in the soil are probably not meaningful in absolute terms, the uniformity with which the areas were sampled and the samples processed was such that it should be possible to use the data in a general way to compare the populations of one area with those of another.

The data of Table 2 are especially interesting because of our knowledge of the cropping history of the fields sampled. Despite the variability among the fields in soybeans and among those in corn, it appears that high counts of Pratylenchus and Helicotylenchus in the soil are associated with corn, whereas high counts of Paratylenchus are associated with soybean cul-

ture. This is most clearly demonstrated by comparing the counts of the Morrow Plots (continuously planted to corn) with those of Field 1101 (continuously planted to soybeans). The three highest counts for Pratylenchus were from the three fields in the study that had been planted to corn both in 1956 and 1957. Of the fields with the highest counts of Helicotylenchus, three out of four were in corn in 1957. The fields with the third highest count was in soybeans in 1957, but was in corn the 2 previous years. A fairly high count of Helicotylenchus was observed from the soil of the wooded area never under cultivation, but this was a species different from that of the other soil samples.

By way of contrast, fields with two out of three of the highest counts for Paratylenchus were in soybeans in 1957. Field M2N, which also had a high count of Paratylenchus, is an interesting exception. Before the 2 years of corn in 1956 and 1957 this field was in clover for 2 consecutive years. It is possible that high populations built up on the clover crop and that large numbers of the nematodes remained in the soil in a dormant state during the period in which the area was planted to corn. By way of substantiation of this speculation, it can be noted that all the Paratylenchus counted from this field were in a pre-adult, non-feeding state. In the fields planted to soybeans some adult females were always seen. Usually these comprised nearly half the total number of Paratylenchus counted.

From Table 1 it is interesting to note that the four locations where Helicotylenchus was not found are the four locations which were not planted to corn the previous year (1956). The two fields planted to soybeans in 1956 both had low counts of Pratylenchus and comparatively high counts of Paratylenchus.

One species of Pratylenchus, identified as P. hexincisus Taylor and Jenkins, 1957, seemed to be prevalent throughout all the fields sampled. There was at least one other species present also, in small numbers, in several Urbana fields and in the soil from Newton. All of the Helicotylenchus from the cultivated areas appeared to be an unidentified monosexual species of the erythrinae type. In the uncultivated woods another species was found. What appeared to be a single species of Paratylenchus was present throughout the State with small numbers apparently of two or three additional species in a number of samples. Tylenchorhynchus acutus Allen, 1955, was widespread throughout the State. It was the species recovered in large numbers from the soil taken at Carrollton. Soil from Urbana fields contained this species as well as T. maximus Allen, 1955, and at least one other species, which was also recovered from several other locations. Meloidogyne hapla Chitwood, 1949, was found in roots of the soybean variety Perry from a farm 2 miles southof the Miller City location.

As yet there are no data to indicate whether or not any of these nematodes are injurious to crops in the soils from which they were recovered. The only instance noted of obvious root injury from some cause was in soybean plants from Carrollton. The soil from which the plants were taken had high counts of Paratylenchus sp. as well as very high counts of Tylenchorhynchus acutus. As a first step in determining whether or not nematodes are causing injury in these Illinois soils, a fumigation experiment is now being carried out in a selected area on the Agronomy Farm at Urbana.

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WEED HOSTS OF MELOIDOGYNE INCOGNITA IN INDIANA

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Since the splitting of the root-knot nematodes by Chitwood[1] into several species, each with a distinct host range, it has become necessary to determine which plants of the earlier-described host range are attacked by each species. This report lists the common weed hosts of Meloidogyne incognita (Kofoid and White) Chitwood and M. incognita var. acrita Chitwood in Indiana as determined by testing in the greenhouse. No effort was made to distinguish between the species and its variety, as both were obtained from the initial sample collected near Owensville in southern Indiana[2].

The nematodes were increased on Kentucky pole beans and Bansei soybean, both of which are highly susceptible. Plants were tested by growing them for 45 days in soil infested by the addition of large amounts of chopped, galled roots. Plants were considered susceptible when their roots had mature females develop on them and resistant when the roots did not have mature females. Since it was desired to determine which plants would maintain the population of root-knot nematodes in the field, these two classes were chosen.

Most of the weed plants tested were selected from the common weeds of Indiana reported in "Weeds of the North Central States"[3]. However, not all the common weeds were tested. The first list presents those classed as susceptible; those starred (*) were noted to be highly susceptible. The second list presents the plants that were resistant in this test, that is, their roots had no adult females. A negative test is necessarily not as definite as a positive result because of the problem of variable levels of the population of nematodes and the possibility of escapes.

Susceptible

Avena fatua (wild oats)
Echinochloa crusgalli (barnyard grass)
Digitaria sanguinalis (large crabgrass)
Eleusine indica (goosegrass)
Muhlenbergia schreberi (nimblewill)
Panicum capillare (witchgrass)
Allium canadense (wild onion)
*Polygonum aviculare (knotweed)
P. erectum (erect knotweed)
P. coccineum (swamp smartweed)
P. convolvulus (wild buckwheat)
P. pensylvanicum (Pennsylvania smartweed)
*P. persicaria (ladythumb)
Rumex acetosella (red sorrel)
R. altissimus (smooth dock)
R. crispus (curled dock)
R. obtusifolius (broad-leaved dock)
Chenopodium album (lambsquarters)
C. ambrosioides (Mexican tea)
Amaranthus albus (tumbleweed)
*A. graecizans (prostrate pigweed)
A. spinosus (spiny pigweed)
*A. retroflexus (redroot)
Phytolacca americana (pokeweed)
Portulaca oleracea (purslane)
Stellaria media (chickweed)
Brassica juncea (Indian mustard)
Capsella bursa-pastoris (shepard's purse)
Raphanus raphanistrum (wild radish)
Sisymbrium officinale (hedge mustard)
Medicago lupulina (black medick)
Oxalis stricta (yellow wood sorrel)
Acalypha virginica (three-seeded mercury)
Euphorbia maculata (nodding spurge)
E. supina (prostrate spurge)
Abutilon theophrasti (velvet leaf)
Hibiscus trionum (Venice mallow)
Malva neglecta (cheeses)
Daucus carota (wild carrot)
Pastinaca sativa (wild parsnip)
Apocynum cannabinum (dogbane)
*Ampelamus albidus (climbing milkweed)
Asclepias syriaca (common milkweed)
Convolvulus sepium (hedge bindweed)
*Ipomoea hederacea (ivy-leaved morning glory)
I. purpurea (annual morning glory)
I. lacunosa
Leonurus cardiaca (motherwort)
Physalis heterophylla (ground cherry)
*Solanum dulcamara (bitter nightshade)
S. nigrum (black nightshade)
S. rostratum (buffalo bur)

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[1]Chitwood, B. G. 1949. Root-knot nematodes -- Part I. A revision of the genus Meloidogyne Goeldi 1887. Proc. Helmin. Soc. Wash. 16: 90-104.

[2]Appreciation is expressed to Dr. G. F. Warren, Department of Horticulture, Purdue University, for assistance in obtaining the initial inoculum.

[3]Weeds of the North Central States. 1954. North Central Regional Pub. No. 36.

Susceptible (Continued)

Linaria vulgaris (yellow toadflax)
Verbascum blattaria (moth mullein)
*Plantago lanceolata (buckhorn plantain)
P. rugelii (Rugel's plantain)
Sicyos angulata (bur cucumber)
Centaurea maculosa (spotted knapweed)
Cirsium vulgare (bull thistle)
C. arvense (Canada thistle)
Erigeron canadensis (horseweed)
*Lactuca scariola (prickly lettuce)
L. canadensis (tall lettuce)
L. pulchella (blue lettuce)
Sonchus oleraceus (sowthistle)
S. arvensis (perennial sowthistle)
Taraxacum officinale (dandelion)
Tragopogon pratensis (yellow goatsbeard)
Vernonia altissima (tall ironweed)
Xanthium pennsylvanicum (cocklebur)

Resistant

Aegilops squarrosa
Agropyron repens (quackgrass)
Andropogon furcatum
Cenchrus pauciflorus (sandbur)
Eragrostis pectinacea
Hordeum jubatum (squirrel tail)
Panicum dichotomiflorum (fall panicum)
Sorghum halepense (Johnsongrass)
Cyperus esculentus (yellow nutgrass)
Mollugo verticillata (carpetweed)
Potentilla recta (upright cinquefoil)
Euphorbia cyparissias (cypress spurge)
Oenothera biennis (evening primrose)
Verbena urticaefolia (white vervain)
Nepeta cataria (catnip)
Datura stramonium (jimson weed)
Solanum carolinense (horse nettle)
Achillea millefolium (yarrow)
Ambrosia artemisiifolia (ragweed)
A. psilostachya (perennial ragweed)
A. trifida (giant ragweed)
Amphiachyris dracunculoides (broomweed)
Aster pilosus (white heath aster)

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CONTROL OF FLOWER BLIGHT OF CAMELLIAS IN LOUISIANA WITH FUNGICIDES

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Flower blight of camellias (Sclerotinia camelliae Hara) was first found in Louisiana in Shreveport and Monroe in 1950 and the following year in New Orleans. Since these original infestations were limited to a few properties, it was hoped that it might be possible to eradicate the disease from these few infested areas, and all early efforts at control were directed toward eradication. Shreveport, through the leadership of its Mens' Camellia Club, initiated a concerted clean-up campaign in 1951 which, for awhile at least, appeared to succeed, as no blight was found in that city during the 1953 and 1954 blooming seasons. However, blight was prevalent and severe in Shreveport in 1957 and 1958, showing that the eradication efforts were unsuccessful. In New Orleans no serious effort was made in the beginning to eradicate the blight from the few properties on which it was originally found, and in spite of quarantine restrictions, it spread to several neighboring properties during the ensuing four years. In 1956 and 1957 the State Department of Agriculture, in cooperation with local interests, put forth drastic efforts designed to test the feasibility of eradicating the blight from New Orleans. The grounds of every known infested property (133 properties in 1956 and 859 in 1957) were sprayed twice each season with ferbam, and attempts were made to collect and burn all fallen blossoms. As an eradication measure, this concerted, large-scale effort was a failure; the blight was not eradicated. On the other hand, the incidence of blight in New Orleans during the 1956, 1957 and 1958 seasons was definitely light, suggesting that the control measures described had helped to reduce the amount of infection.

With the continuing dissemination of the blight fungus in the South (it is now known to occur in most of the southern States -- Texas, Louisiana, Georgia, South Carolina, North Carolina, Virginia) it is becoming more and more evident that eradication is impractical, if not impossible. The disease is here to stay, and camellia fanciers must learn to "live with it." This is not meant to imply that restrictive measures and practices to delay its spread should be abandoned. There are still vast areas in the South in which the disease has not become established, and every effort should be made to keep it out of these areas. It is particularly important to keep it out of centers of commercial nurseries. Quarantine regulations governing the movement of plant material should be strictly enforced, and individual growers should resist the temptation to risk the transportation of camellias from an infested to a non-infested area. Also, prompt drastic eradicant measures, such as complete debudding of plants and chemical treatment of mulch and soil, should be used to eradicate the disease from small localized centers of infection in an otherwise blight-free area.

At best, all these measures are but delaying tactics calculated to slow the rapid dissemination of the disease as long as possible. Judging by the history of blight fungus in California, where its spread was very rapid, and by the fact that in the relatively short period of the past ten years the disease has gained a firm foothold in several localities in the South, it is reasonable to predict that it will not be long before blight has become well established in the camellia growing areas of all southern States. When this happens, exclusionary measures will be of little value and other means of lessening the ravages of the disease must be found. An inherent weakness of the blight fungus is its lack of a conidial stage. Because of this, there is no secondary spread from flower to flower; all infection must come from ascospores from apothecia arising from sclerotia in the soil. Any method that will inhibit apothecial formation will give control of the blight. Fungicidal chemicals applied to the soil or mulch would seem to offer the most practical method of inhibiting the development of apothecia.

A number of workers have found that apothecial development of Sclerotinia camelliae can be suppressed with soil applications of chemicals such as captan, ferbam, sulfur, Terraclor, cyanamide, and Krenite-26. Thomas and Hansen (4) reported that ferbam applied to the soil at the rate of 4 pounds per 100 gallons of water would suppress apothecial development but would not kill mature apothecia. Harvey and Hansen (3) found that ferbam used as a soil drench at the rate of 6 pounds per 1000 square feet with wetting agents suppressed apothecial development. Also, sulfur applied at a concentration of 0.05 pounds per square yard gave similar results. Hanson (2) used captan at 2 pounds per 100 gallons as a soil spray and reported a 90 percent reduction in blighted flowers. Haasis and Nelson (1) found several chemicals to be effective in suppressing apothecial emergence. Among these were pentachloronitrobenzene (Terraclor) used at the rate of 200 pounds per acre, cyanamide at 400 pounds per acre, and a 1 percent solution of Krenite-26 at 800 gallons per acre. They found

no evidence of plant injury resulting from the use of these chemicals.

This study was made for the purpose of obtaining information on the effectiveness of fungicides as inhibitors of apothecial development when used as soil drenches under Louisiana conditions. Twenty plots, each 1 square yard in area, were marked off beneath large camellia plants by using a 3 foot x 3 foot metal frame. These plots were arranged at random in a blight-infested garden in Shreveport, Louisiana. Each treatment was replicated four times. During the spring of 1957 a large number of diseased flowers were collected from this garden and placed in a room maintained at 14° C, 12 hours of light and 12 hours of darkness, and high humidities. After about one month the sclerotia were separated from the flowers and stored in the same room until May 29 of the same year. At this time 100 large sclerotia were placed in each square yard plot in two lines of 50 sclerotia each which bisected each other at right-angles to form four radii of 25 sclerotia each. The sclerotia were placed in the soil at a depth of approximately 1/2 inch. Since blight had been very severe in this garden, many sclerotia, in addition to the planted ones, were naturally present in the mulch and soil.

All fungicides were applied as soil drenches at the rate of 300 pounds per acre for the first time on January 4, 1958 and again on the 30th of the same month. Two gallons of water per plot were used as a carrier in applying the chemicals. The chemicals were applied with a John Bean, Model 33 Spartan 15-gallon sprayer equipped with a pair of nozzles containing No. 8006 Tee jets.

At the time of the first application some of the sclerotia in the plots had germinated and the stipes were approximately 1/2 inch long but no apothecia were found. However, by the time of the second application a few expanded apothecia were found in the check plots.

The data were recorded at two different dates by removing and counting the apothecia occurring on the soil surface of each replicate plot. The first count was made on February 15, 1958 and the second 23 days later. The total number of apothecia collected on both dates for the respective treatments are given in Table 1.

Table 1. Number of Sclerotinia camelliae apothecia appearing in 1-square yard plots which were artificially infested with 100 sclerotia.

Treatment	Number of apothecia per plot				
	Replications				
	1	2	3	4	Totals
Check (water alone)	64	89	57	96	306
Sulfur (wettable, 95%)	79	57	52	35	223
Captan (N-trichloromethylmercapto-4-cyclohexene-1:2-dicarboximide, 50% W. P.)	6	4	25	6	41
Ferbam (ferric dimethyldithiocarbamate, 75% W. P.)	11	4	0	0	15
Terraclor (pentachloronitrobenzene, 75% W. P.)	0	2	0	0	2*

*This figure represents 2 stipes on which apothecial initials had started to develop but appeared to have been injured by the chemical.

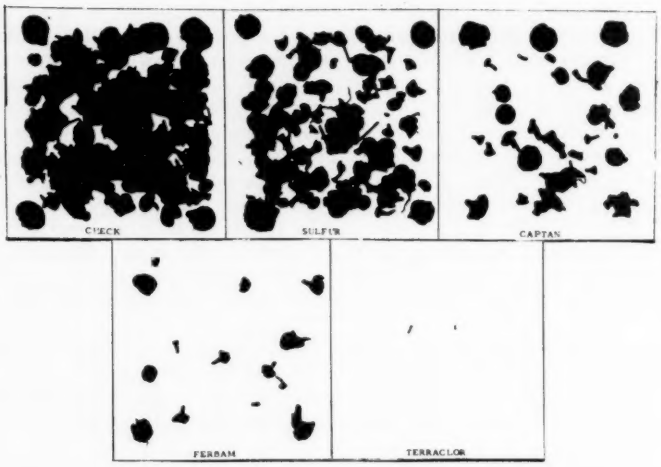

FIGURE 1. Number of apothecia found in each treatment (four replicate plots).

These figures show that all fungicides tested suppressed apothecial development to some extent; however, only Terraclor completely inhibited the development of normal apothecia in the treated plots. In plot number 2 of the Terraclor test, the figure represents 2 stipes on which apothecial initials had started to develop, but these appeared to have been injured by the chemical (Figure 1). The Terraclor plots were examined again on March 28 and found to be free of apothecia; numerous apothecia were found in the check plots at this time. Figure 1 shows a composite sample of the apothecia obtained on the second counting from the four replicate plots within each fungicide test. No evidence of plant injury was found resulting from the use of these chemicals.

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COMPARATIVE EFFECTS OF FUMIGATION WITH CHLOROPICRIN AND METHYL BROMIDE ON MINERALIZATION OF NITROGEN IN EVERGLADES PEAT[1]

J. P. Winfree and R. S. Cox[2]

Abstract

Fumigation of Everglades peat in situ with either chloropicrin or methyl bromide resulted in an initial accumulation of ammonium nitrogen at the expense of nitrate nitrogen. This apparently was the consequence of temporarily restricted nitrification. Most of the ammonium that accumulated was oxidized to nitrate in about 2 months.

The accumulation of ammonium and its subsequent conversion to nitrate generally followed the same pattern in the case of both fumigants, the chemically detectible differences being (a) a slightly faster initial increase in ammonium, and (b) a somewhat slower subsequent decrease in ammonium in soil "partially sterilized" with methyl bromide.

INTRODUCTION

In research reported earlier (7) fumigation of an organic soil in situ with chloropicrin was found to exert a decided influence on the kinetics of nitrogen mineralization. Ammonium nitrogen accumulated at least 10-fold following fumigation, at the expense of nitrate nitrogen. The accumulation was followed, however, by replacement of the ammonium nitrogen with nitrate nitrogen. This sequence of events suggested that the fumigation was responsible for an inhibition of nitrification, that this led to the accumulation of ammonium nitrogen, and that the nitrate nitrogen formed as the microbial nitrifying system recovered.

The two experiments reported here were designed (a) to evaluate the results of the other work on a larger field scale, and (b) to compare the effects of chloropicrin with those of methyl bromide, when both materials are used according to recommended rates and methods of application for control of soil pests.

EXPERIMENTAL

The experiments were conducted on Everglades peat which contained more than 90 percent organic matter. Chloropicrin was applied with a hand injector at about 1.3 pounds per 100 square feet. Methyl bromide (98% plus 2% chloropicrin) was applied at 2 pounds per 100 square feet under polyethylene sheeting which was removed after 48 hours. Nitrogen was not included in the fertilization of the plots. Samples of soil taken periodically to 6-inch depth were analyzed immediately for ammonium nitrogen, nitrate nitrogen, and moisture, according to the procedures employed in the earlier study (7). Contents of nitrogen are expressed as ppm of oven-dry soil.

The first experiment involved fumigation with chloropicrin of a relatively large (50 foot x 50 foot) block of land at the Everglades station that was planted 10 days after treatment to a spring, 1957, crop of Iceberg lettuce. A similar block nearby was left untreated. Otherwise, both blocks were handled identically. Water table depth was maintained at about 18 inches.

The second experiment, during the summer of 1957, included check, chloropicrin, and methyl bromide treatments in 4 foot x 25 foot sub-plots randomized on 25-foot-square water-table plots used in the previous study (7).

RESULTS

Forty-three days following the fumigation in the first experiment, ammonium nitrogen had reached at least 85 ppm in the fumigated block (Figure 1). Judging from previous work (7) and

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[2] Assistant Soils Chemist and formerly Associate Plant Pathologist, respectively. The writers are indebted to Nelson Nelms for supervision of the field work, to E. King, Jr. for preparation of the graphs, and to Charles Butts for soil sampling and analysis.

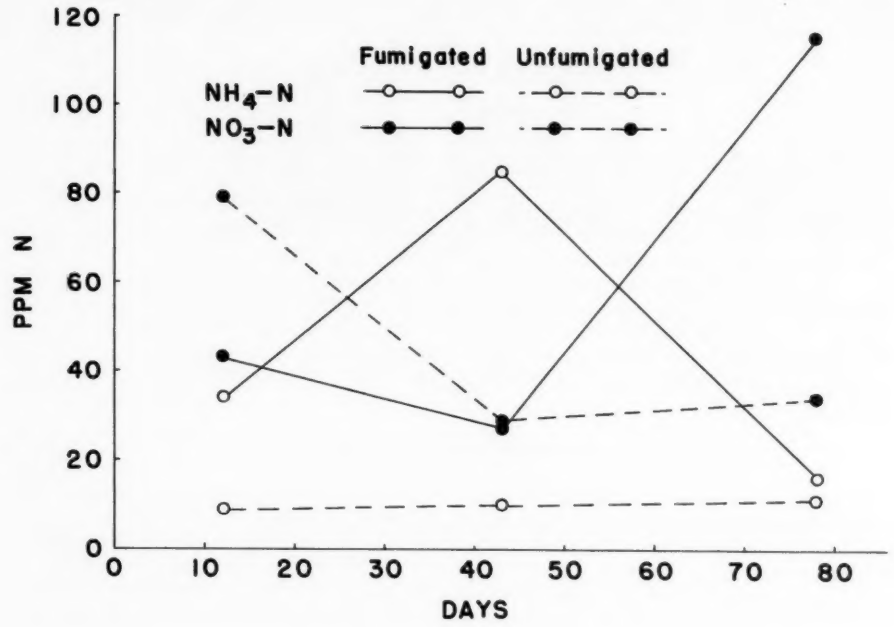

FIGURE 1. Ammonification and nitrification in Everglades peat as influenced by fumigation with chloropicrin. Each point represents the mean of duplicates.

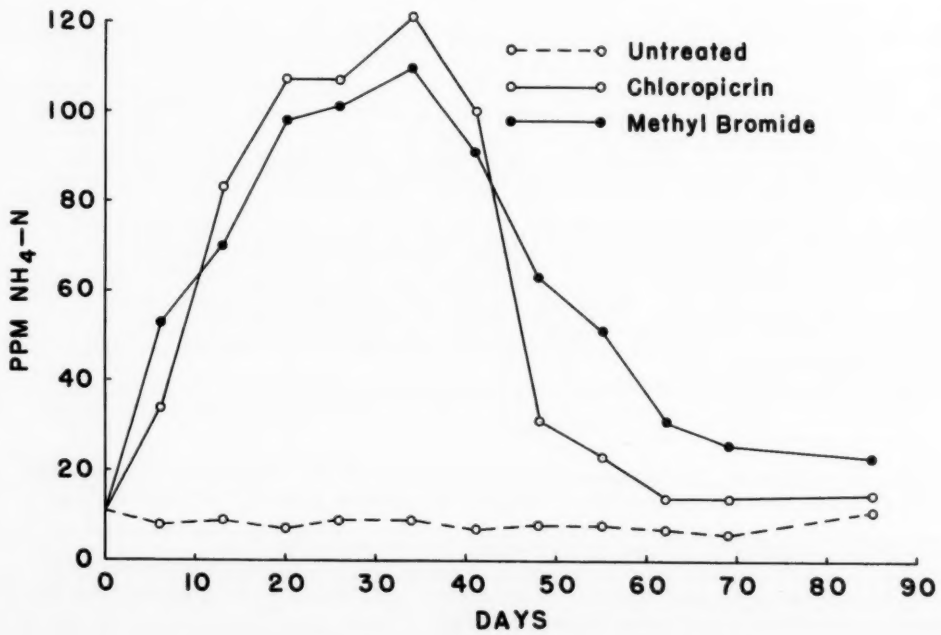

FIGURE 2. Ammonium levels in Everglades peat as influenced by fumigation with chloropicrin or methyl bromide. Each point represents the mean of three determinations.

results reported in Figure 2, ammonium nitrogen probably had reached an even higher concentration, the 85 ppm occurring some time after the maximum was attained. The maximum level of ammonium nitrogen recorded in the untreated block was 11 ppm. In the treated block, levels of ammonium nitrogen and nitrate nitrogen were the same (about 60 ppm) at an estimated 55 days after treatment. After 80 days nitrate nitrogen had almost completely replaced the ammonium nitrogen which, by that time, had fallen to 16 ppm, a concentration near that occurring in the untreated block.

In the second experiment the patterns of mineralization that resulted from the fumigation treatments are illustrated in Figure 2. In this figure the levels of ammonium nitrogen occurring in the respective plots have been plotted against time. Both fumigation treatments caused ammonium nitrogen to accumulate for about 30 to 40 days. The maximum concentration measured was not quite as high in the methyl bromide-treated plots as in the chloropicrin plots (110 ppm versus 121 ppm at 34 days), although it increased at a faster rate initially (during the first week). Further, ammonium nitrogen did not decrease quite as rapidly after the maxima were attained or fall to as low a level in the methyl bromide plots as it did in the chloropicrin plots. After 85 days 23 ppm occurred in the methyl bromide plots, versus 15 ppm in the chloropicrin plots. This suggests that there may have been a slight residual effect of this treatment to depress nitrification. Except for these relatively small differences, however, the effects of the two treatments were similar, and for practical, cultural purposes, the same.

DISCUSSION

The manifold effects of soil fumigation have received a considerable amount of attention in the past. One of the most important consequences of such treatments, one which has been thoroughly stressed (2, 3, 4, 5, 6), is the increased amount of "available" nitrogen that occurs in fertile soil following fumigation, particularly as it affects the nutrition of plants.

In the Everglades crops are produced under adverse conditions, from the standpoint of diseases, insects, and weeds, in soils comprised for the most part almost entirely of organic matter. Here, fumigation with materials such as methyl bromide and chloropicrin often is a prerequisite to profitable production of certain crops. Consequently, when the breakdown of organic matter and the conversion of it into substances that function as plant nutrients (ammonium nitrogen and nitrate nitrogen) apparently are affected so drastically by fumigation, considerable benefit should be gained from an understanding of what happens when the practice is employed.

In addition to confirming earlier results and revealing certain similarities and differences between two of the most commonly used and recommended soil fumigants, the results of these experiments support and give a basis for the observation of growers and researchers that certain plants growing in fumigated organic soil, but receiving supplemental nitrogen, do not respond to the nitrogen to the same extent that they do in fumigated soil (1). Also it has been observed in the Everglades and elsewhere (5) that young plants in fumigated seedbeds react less favorably to ammonium sources of nitrogen than they do to nitrate sources. It has been claimed (5) that nitrate actually may counteract detrimental effects of too much ammonium. While this may be so, data presented to support the conclusion indicated that the benefit came from substituting nitrate for ammonium nitrogen in the fertilization, rather than from overcoming the apparent toxicity of ammonium with additional nitrogen as nitrate.

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THE USE OF TILES FOR STUDIES ON SOIL-BORNE FUNGI

Charles J. Gould[1]

Summary

Concrete sewer tiles have proven very useful for certain types of field studies on soil-borne pathogens, including: the longevity of pathogens in different soil types; the effectiveness of different kinds of fungicides; the effectiveness of different methods of fungicide application; and the persistence of fungicidal action in the soil. Other possible applications are listed.

Soil-borne diseases of ornamental bulb and corm crops have become increasingly important in western Washington in recent years. The three fungi causing the most serious losses are: Stromatinia gladioli (Dray.) Whet. on gladiolus, Sclerotium rolfsii Sacc. and an unnamed (black rot) fungus. The latter two parasites may attack several types of bulbs, but have been most serious on bulbous iris.

Much progress has been made in controlling the bulb-borne phase of these fungi, but research on the etiology and control of their soil-borne phase in commercial fields in western Washington has been difficult because of the usually spotty nature of the infestation, the high price of the crops, and the large amount of hand labor involved. For these reasons, two alternatives to commercial fields were considered: 1) The use of experimental fields in which a heavy infestation was built up by artificial means; or 2) The use of small isolated plots. The small plots were chosen for preliminary tests, and artificially-infested fields selected for use in certain additional and larger-scale studies.

The possibility of using small field plots separated from each other by concrete, metal or transite walls was discarded, for practical reasons, in favor of concrete sewer tiles[2]. Experiments with the tiles were started in 1952 and their use was described briefly by the author in 1956 (2). Since then he has learned that Brandes (1) used similar tiles in 1915 to establish pathogenicity of the banana wilt pathogen. Although the technique is therefore not new, the details of tile use and certain applications are reported here in response to several requests for the information.

Non-reinforced tiles with an inside diameter of 30 inches were selected because they were cheaper than the 36-inch size. The "belled" type was used to reduce the danger of contamination by splashing. Tiles were placed in a field in double rows 2 feet apart (Fig. 1). The double rows of tiles were spaced 9 feet apart to allow passage of a pickup truck for adding or removing soil. The tiles were sunk 18 inches into the soil and surrounded by 6-inch layer of sawdust to reduce weed growth and the danger of contamination by splashing with water. Wire screens were placed over the tiles to keep out birds.

A very light sandy subsoil originally was placed in the bottom of the tile. At the start of a new experiment the desired experimental soil type is added to the level of the outside soil surface. Giant oat cultures are incorporated into the topsoil with a Rotolectric mixer (Model E. Serial No. 73 made by the Rotolectric, Inc., Troy, N. Y.).

The soil is usually allowed to "set" for 1 to 2 weeks after being infested before being planted or treated with fungicides. These are added to the soil by drenching or mixing with the electric mixer. After the desired interval of 1 or more weeks, depending on the materials being tested, the topsoil is removed to the depth of planting and is placed temporarily in formalin-disinfected cans while the bulbs are being planted. Bulbs are usually harvested by screening the topsoil. This is discarded and the subsoil sterilized with formalin before another experiment is started.

Four replications were used per treatment in the first experiments and four are still used whenever possible in certain types of studies. However, the results were sufficiently consis-

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[1] Plant Pathologist, Western Washington Experiment Station, State College of Washington, Puyallup, Washington.

[2] Grateful acknowledgment is made to the Olin Mathieson Chemical Corp. and Pennsylvania Salt Mfg. Co. for grant funds for tile purchases.

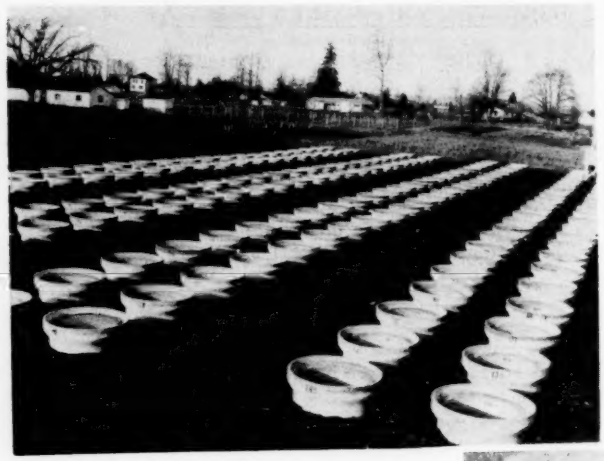

FIGURE 1. Field view of tile layout for studies of plant diseases caused by soil-borne organisms.

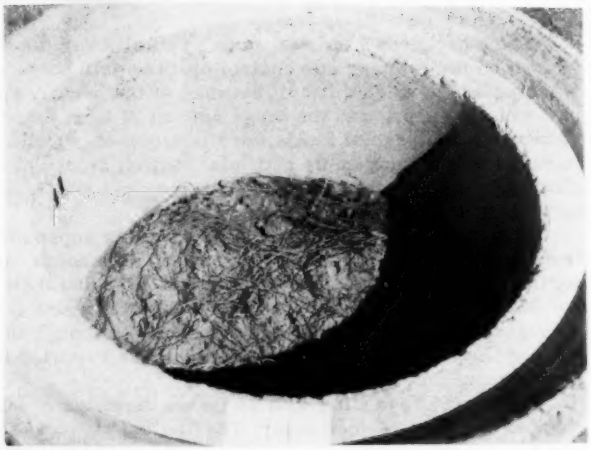

FIGURE 2. Use of concrete tile for studies of plant diseases caused by soil-borne pathogens. Soil infested with the black rot fungus. Untreated. Planted with 100 bulbous iris (variety Wedgwood).

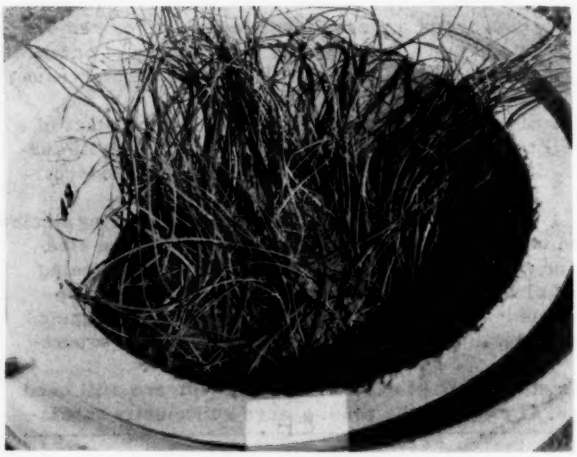

FIGURE 3. As in Figure 2, but soil treated with pentachloronitrobenzene at rate of 150 pounds active per acre.

tent in the first experiments to justify reducing the replications to three in subsequent fungicidal screening tests. Occasionally, one replication will give apparently inconsistent results, but this variability is taken into consideration when appraising the general results.

Plant growth has been normal in the tiles. The main difficulty has been the tendency of soil to develop cracks, particularly next to the tile surface. This has been partially overcome by occasional heavy watering or stirring the soil with a stick.

Of course, the tiles are not adapted to the testing of fungicides by strip or furrow application.

In experiments since 1952, tiles have proven useful for such studies as:

1. Longevity of soil-borne pathogens in different types of soils.
2. Effect of temperature on disease development (soil heating cables were used).
3. Relation of fertilizers to infection.
4. The effect of bulb treatments on the control of certain pathogens that we did not wish to risk letting "escape" into our experimental fields.
5. Fungicide testing, including studies of:

    A. Types of fungicides (Figs. 2, 3).
    B. Rates of fungicide application.
    C. Methods of application (mixing, injecting, and drenching).
    D. Comparative effectiveness of coating bulbs with fungicides, versus soil application.
    E. Effect of different soil types on fungicidal effectiveness.
    F. Persistence of fungicides in the soil for more than one season.

Under current investigation are the effects of various amendments on disease development in iris bulbs planted in non-infested soil and in soil infested with S. rolfsii, with some of both treated with pentachloronitrobenzene and not treated.

The tiles are just one more tool to use in studying diseases caused by soil-borne organisms. In fungicidal screening, the first step should usually be a laboratory test (preferably using soil), followed by greenhouse tests. (A Twin Shell blendor manufactured by the Patterson-Kelley Co. has proven very helpful in mixing inocula and fungicides with small quantities of soil. A powered cement mixer can be used for larger quantities.). The materials shown to be most effective would then go successively into tile tests outdoors, artificially-infested fields, and, finally, commercial fields. It has not always been possible to follow this "preferred" program. However, in general, we believe that the use of tiles has put us at least 2 or 3 years ahead of the research possible when using only naturally, or even artificially, infested fields. In addition, certain factors affecting disease development, such as different soil types, temperatures, moisture contents, and nutrient levels, would be very difficult, if not impossible, to compare under uncontrolled field conditions. Tiles might also prove useful for studies such as the relation of nematodes to fungus attack, beneficial effect of antagonistic organisms, and controlled studies of nutrition. Hacskaylo and Palmer (3) have recently described the use of tiles in mycorrhizal studies.

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SOIL TEMPERATURE TANKS WITH POLYETHYLENE FILM LINERS[1]

John L. Lockwood and J. C. Ballard[2]

Several types of soil temperature tanks have been described for use in studies of the effects of temperature on root diseases or in the evaluation of seedling resistance to root diseases (1, 2, 3, 4). Most of these are rather elaborate in design and are expensive. The tank described herein is a wooden box lined with a polyethylene film. It is of comparatively simple and inexpensive construction and can be built by unskilled labor. Most of the equipment used is listed by scientific supply companies. A series of four such tanks is in use in the Department of Botany and Plant Pathology of the Michigan Agricultural Experiment Station.

A wooden box was constructed of 1 1/2-inch rough lumber (Fig. 1). Outside dimensions of the box were 37 x 39 x 28 inches deep; inside dimensions were 34 x 36 x 26 1/2 inches deep. Legs made of 9-inch lengths of 1 1/4-inch pipe were set in flanges screwed to the bottom of the box. A 3/4-inch vertical overflow pipe entered the box through a hole drilled near a top corner, the angles being made by 90° elbows. The overflow drained into a horizontal pipe near the floor.

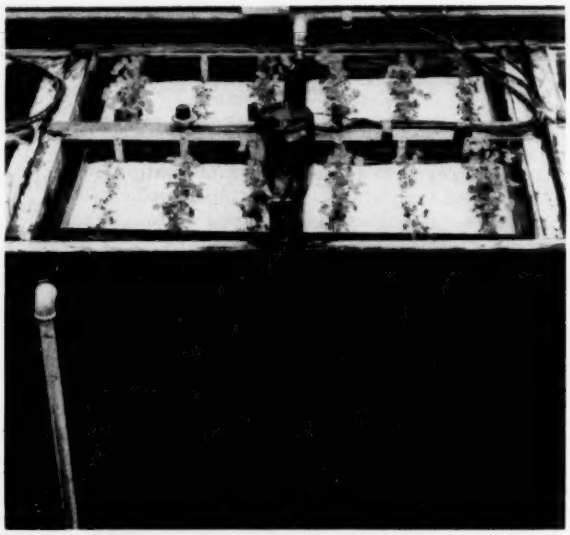

FIGURE 1. Soil temperature tank made of wooden box lined with polyethylene film and containing four pans with pea seedlings. Note water tap at rear, heater and thermoregulator at center, stirrer at front, and overflow at left-front.

Polyethylene film (Visqueen film, Visking Co., Division of Union Carbide Co., Terre Haute, Ind.) of 6 mil thickness was used to make a waterproof liner for the box. Water was added to a depth of about 2 inches to facilitate fitting the film to the bottom, corners, and sides. The excess material was folded against the sides and the edges were fastened to the top edge of the box with battens. A hole was cut in the film at a position corresponding to the overflow pipe. The plastic film, a rubber gasket, and a metal washer were placed over the overflow pipe, and the elbow was replaced. A water-tight seal was made by tightening a hexagonal nut against the outside of the box.

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[1] Journal Article No. 2259 , Michigan Agricultural Experiment Station. Assistance of Roy A. Twichell is acknowledged.

[2] Staff member of Department of Botany and Plant Pathology and Department of Horticulture, respectively.

A waterline with outlets at the rear of each tank was installed. Brass stopcocks were used as flow of water was more easily controlled with these than with conventional faucets. Water was allowed to run slowly into the tanks to effect cooling should the air temperature be higher than the desired water temperature, and to replace water lost by evaporation.

A 1000 watt immersion heater (Model 14062H 47B, Cutler-Hammer Co., Milwaukee, Wis.) was wired to a thermoregulator (Catalog No. 17550-0, Fenwal Inc., Ashland, Mass.) of the type not requiring a relay. A small light was wired into the circuit to indicate when the heater was in operation.

The thermoregulator and heater were placed in holes appropriately drilled in a board 39 x 1 3/4 x 3/4 inches which was placed across the top of the tank at the center (Figs. 1 and 2). Later, a more convenient combination thermoregulator and heater (Model No. T-H 2007, Blue M Electric Co., Blue Island, Ill.) was used. This unit required no wiring or relay and was fastened to a board attached to the side of the tank.

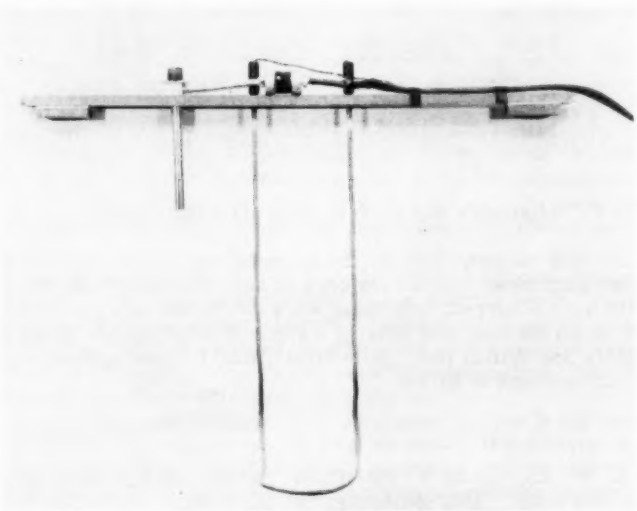

FIGURE 2. Heater and thermoregulator in supporting board.

One of the tanks was equipped with a refrigeration compressor (Model No. W50S U, Tecumseh Products Co., Tecumseh, Mich.). The coil was placed on a wooden rack in the bottom of the tank. A thermoregulator (Catalog No. 17551-0, Fenwal, Inc., Ashland, Mass.) was used to control operation of the compressor motor.

Each tank was equipped with an electric stirrer (Lightning Model L mixer, Mixing Equipment Co., Rochester, N. Y.) which was mounted on a board attached to the front of the tank. Except for hot summer days, use of stirrers was not necessary to maintain uniform temperatures.

An adjustable stand was constructed for holding crocks or pans in which plants were grown (Fig. 3). The stand consisted of a top and a bottom section, and was made of 2 x 4's. Four 10-inch lengths of 5/8-inch pipe (OD 7/8 inch) with holes drilled through at 1/2 inch spaces were set into flanges screwed to the four corners of the top section. Four 10-inch lengths of 1-inch pipe were set into flanges correspondingly screwed to the bottom section. Thus, the upper four pipes would fit inside the lower pipes. Adjustment of height over a distance of about 8 inches could be accomplished by raising or lowering the upper section and inserting nails through the the holes in the upper pipes. Pieces of foam rubber were nailed to the underside of the bottom section to prevent abrasion of the polyethylene film. A frame made of 3/4-inch lumber placed over the stand to accommodate the plant containers. For much of our work galvanized steel pans 13 1/2 x 15 1/2 x 4 inches deep have been used. Four such pans fit conveniently into each tank.

The temperature tank can be operated at almost any desired temperature by adjustment of the thermoregulator and the flow of water. When temperatures considerably below that of the air or tap water are desired, the refrigeration unit is used. Temperatures can be controlled to $\pm 1^{\circ}C$.

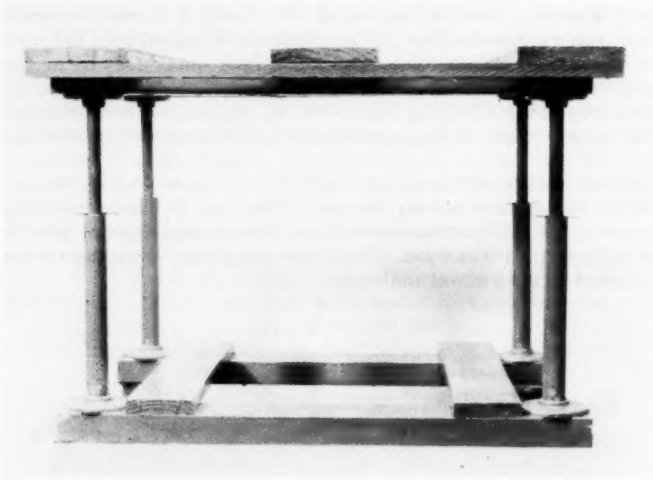

FIGURE 3. Adjustable stand for holding plant containers.

Though not as durable as metal liners, the polyethylene liners have proved entirely satisfactory. Tanks fitted with these liners have been in nearly constant use for over 2 years. Accidental tears rarely have occurred, and these were easily and quickly repaired by siphoning the water to a point below the tear and affixing a piece of polyethylene to the hole with an adhesive (Goo, Walther's Specialties Inc., Milwaukee, Wis.). The approximate cost of a polyethylene film liner for one tank is $1.40.

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HOLDING MELTED WATER AGAR FOR POURING PLATES

Robert D. Raabe[1] and Stephen Wilhelm[2]

In the Department of Plant Pathology at Berkeley much of the culturing of fungi is done on plates of natural media (3). The nutrient portion of these media consists of dried plant materials sterilized with propylene oxide vapor (2). In the preparation of Petri plates of natural media a small quantity of the desired plant material is placed in the plate and melted 2% water agar is poured over it. Before solidification of the agar, the dish is rotated to obtain an even distribution of the plant material. To minimize the leaching and diffusion of nutrients from the plant material the agar is cooled to approximately 40° to 50°C before pouring. Thus, in the solidified plate the nutrients in the agar are rich units of plant material, differentially attractive to various fungi and separated from each other by plain water agar. This allows only limited growth of air-borne contaminants (as Mucors, Aspergilli, Penicillia, and bacteria) and at the same time provides, under laboratory conditions, the natural substrate on which many pathogenic fungi grow well and sporulate magnificently.

The cooling of agar to the desired temperatures prior to pouring is time consuming and not always successful, particularly when large numbers of plates are required. These difficulties may be avoided by storing the melted agar in chambers where the temperatures are somewhat above that at which agar solidifies (about 40° C). If the agar is held in cotton-plugged tubes, the holding temperature need be only slightly above 40°C. However, when held this way for prolonged periods, sufficient water may evaporate to change the concentration of the agar. Tightly capped prescription bottles, 200, 300, or 400 ml sizes, are superior to plugged tubes for holding melted agar. They should be held at approximately 50°C to prevent any solidification in the bottles.

Once initiated, a system can be continued so that melted agar is always available. It is not necessary to use all of the agar from a bottle at one pouring since, by using aseptic techniques, the unused portion can be returned to the temperature chamber without danger of contamination. It is important that the melted agar be used within several days because, upon storage of between 10 to 14 days, it may fail to solidify upon cooling. Dating the bottle at the time of melting helps to avoid over-storage.

Immediate storage of the melted agar, following sterilization in the autoclave, has the advantage of precluding the necessity for re-melting the agar. When plates are poured frequently the storage of melted agar affords additional time-saving as well as convenience.

The technique seems to be advantageous only where water agar is used, as in the pouring of natural media plates, or in any of the modifications of the single-sporing technique first described by Hansen and Smith (1). If agars containing sugars are held for any length of time carmelization takes place and the media darkens.

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1. HANSEN, H. N., and RALPH E. SMITH. 1932. The mechanism of variation in imperfect fungi: Botrytis cinerea. Phytopathology 22: 953-964.
2. HANSEN, H. N., and WILLIAM C. SNYDER. 1947. Gaseous sterilization of biological materials for use as culture media. Phytopathology 37: 369-371.
3. SNYDER, WILLIAM C., and H. N. HANSEN. 1947. Advantages of natural media and environments in the culture of fungi. Phytopathology 37: 420-421.

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BRIEF NOTES ON PLANT DISEASE OCCURRENCE

A SECOND PHYSIOLOGIC RACE OF SPINACH DOWNY MILDEW

By Frank W. Zink and Paul G. Smith

In 1950 immunity from the spinach downy mildew fungus Peronospora effusa was found in two Plant Introduction lots from Iran, P. I. 140,464 and P. I. 140,467. Immunity in the latter seed lot was shown to be due to a single dominant gene[1] and this source of immunity was subsequently used in the development of several immune varieties, among the first of which were United States Department of Agriculture Hybrid No. 7 and Califlay.

These varieties or breeding stocks containing the immunity gene were tried in various places in California, Washington, Texas, Wisconsin and New York in this country, and in Holland. In each place these lines remained resistant.

In early March, 1958, the senior author noted widespread mildew on the Califlay variety in the Salinas Valley of California. Seed of spinach breeding lines and varieties known to be homozygous immune to the mildew previously encountered were inoculated, along with current commercial stocks of the Califlay variety from three seed firms. All became severely infected with downy mildew. It is evident that a second physiologic race of the downy mildew fungus has appeared which is capable of attacking previously immune spinach varieties.

Known distribution of this second race at present is the Santa Clara Valley, the Salinas Valley, and the Oxnard plain of Ventura County in California.

A search for resistance to this second race of mildew has been started, and there is evidence that the United States Department of Agriculture line 99 x 95 may be resistant.

DEPARTMENT OF VEGETABLE CROPS, UNIVERSITY OF CALIFORNIA AT DAVIS

[1]Smith, Paul G. 1950. Downy mildew immunity in spinach. Phytopathology 40: 65-68.

ONION BLAST IN CONNECTICUT

By Saul Rich

Onion blast has appeared in Connecticut. This disease, much more common during the summer months, is a leaf tip die-back, typically white at first, then turning brown. The symptoms may show after a few hours of bright, drying weather. Some leaves collapse and dry so fast that they retain greenish streaks. Blast was first reported on April 22. During the first 12 days of April, 10 days were cloudy-to-partly-cloudy, and there was some precipitation on 7 of the days. This was followed by a week of continuously clear, dry weather with maximum temperatures of 61° to 76° F. This succession of weather is ideal for inducing onion blast[1].

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN, CONNECTICUT

[1]Jones, L. H. 1944. Relation of weather conditions to onion blast. Plant Physiol. 19: 139-147.

A PHYTOPHTHORA BLIGHT AND ROOT ROT OF STRAWBERRY

By E. L. Felix

A new disease of potential economic importance has been found in a 3 1/2 acre field of Tennessee Beauty strawberries, planted in 1956, and belonging to a berry grower near Portland, Tennessee. Symptoms consisted of root rot and blight of the buds, flowers and leaves, on which sporangia of an unidentified Phytophthora appeared in profusion 3 or 4 days after placing the affected material in shallow water in Petri dishes at 20° C. Typical Phytophthora zoospore formation occurred. Vascular discoloration, as in red stele, has not been observed thus far in any of the plants from this field.

This Phytophthora differs from the red stele fungus in having papillate sporangia, infecting tomato fruits, and growing readily on potato-dextrose agar. It resembles Phytophthora fragariae in the sparse narrow hyphae produced on the strawberry plant, absence of sporulation on agar containing oatmeal and yeast extracts, and evident low temperature relation, since the disease was collected first on March 7, 1958, before beginning of warm weather. The papillate fungus was noted in this collection only in the roots, but in additional material collected on April 28 from the same field it was found only in large blighted spots (water-soaked areas that are similar to those of potato and tomato late blight) of buds, flowers and leaves. It should be stated here that on one occasion abundant, typical, non-papillate sporangia of the red stele fungus were also found to develop on blighted young center leaves of a red

stele-infected plant from another part of the State in 3 or 4 days after moist incubation.

The unidentified papillate Phytophthora differs also from the tomato buckeye rot fungus, Phytophthora parasitica var. terrestris, in morphology, temperature relation and parasitism. The latter does not affect older strawberry plants, except the fruit, but does attack all parts of very young seedlings. The strawberry blight Phytophthora and disease now undergoing thorough study in conjunction with red stele will be described more fully and identity established.

TENNESSEE AGRICULTURAL EXPERIMENT STATION, KNOXVILLE, TENNESSEE

THE SWEETPOTATO WHITEFLY, BEMISIA INCONSPICUA (Q), AS A VECTOR OF A SWEETPOTATO MOSAIC IN SOUTH GEORGIA

By J. H. Girardeau[1, 2]

In 1945 inspectors for the Georgia Department of Entomology found a field of "off type" sweetpotatoes with symptoms suggesting a mosaic type virus infection. Progeny from this field were planted in 1946 and the occurrence of the "off type" was so great that it was ordered destroyed by the Department of Entomology inspectors.

No more of these mosaic-like symptoms appeared in Georgia sweetpotatoes until late summer of 1952. At that time Borders and Ratcliffe[3] began a study which established that the infection was caused by a virus and that it was most likely insect-borne.

The virus has grown in importance since that study and a need existed for positive knowledge as to the exact vector or vectors. A search for the vector or vectors was begun in the summer of 1957 at the Georgia Coastal Plain Experiment Station, Tifton, Georgia.

During this first season of study the two most abundant and likely suspects were of first concern. These species were Bemisia inconspicua (Q), the sweetpotato whitefly, and Empoasca fabalis DeLong, sometimes referred to as the sweetpotato leaf-hopper. Tests were conducted using two potted virus-free plants and one potted virus-infected plant confined in a 32 x 32 mesh screened cage. A culture of the suspect species was introduced into the cage and permitted to build up in population through one generation. The original virus-free plants were then removed and treated with insecticides and held for observation of virus symptoms.

In six such tests using Bemisia inconspicua (Q), five of the tests resulted in transmission of the virus. In parallel tests using Empoasca fabalis DeLong, no transmission occurred.

It is intended that further studies of this whitefly and its relation to the virus will be conducted. It is also planned to seek other vectors of the virus, if they exist, among the insect populations which occur in sweetpotato fields in south Georgia.

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[1]Assistant Entomologist, University of Georgia, Coastal Plain Experiment Station, Tifton, Georgia.

[2]The author gratefully acknowledges the assistance of H. I. Borders, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and T. J. Ratcliffe, Georgia Department of Entomology.

[3]Borders, H. I., and T. J. Ratcliffe. 1954. A mosaic of sweetpotato in plant beds and fields in Georgia. Plant Dis. Reptr. 38: 6-9.

OBSERVATIONS ON INSECTS AND FUNGI ASSOCIATED WITH TAPROOT SURVIVAL OF WHITE CLOVER IN NEW HAMPSHIRE[1]

By R. A. Kilpatrick and G. M. Dunn[2]

Plots of Ladino white clover (Trifolium repens L.) were established at two locations in New Hampshire in 1956 to study fungi associated with diseased roots. One seeding was made on Paxton loam, June 21; the other was made August 10 on Agawam fine sandy loam.

Two samplings were made in the fall of 1956. Each sample consisted of approximately 100 taproots from each location. Relatively little rot was noted on the taproots, although there was some discoloration of the secondary roots. Isolations from diseased roots yielded a number of fungi, primarily Fusarium oxysporum (Schlecht.).

Similar samples were made at approximately 1-month intervals during 1957. Taproots sampled on May 6 were severely chewed and girdled by insects. Numerous larvae were found in soil surrounding the roots. These were identified as the clover root curculio, Sitona spp., by Dr. J. G. Conklin of the Entomology Department. Later, adults of two Sitona spp., S.

hispidula (F.) and S. flavescens (Marsh.), were found in clover fields throughout New Hampshire. Most of the insect injury was within 2 inches of the crown, although some injury was observed on taproots at a depth of 5 to 6 inches The greatest amount of injury occurred in the spring and fall, corresponding to the periods of greatest larval populations.

Root rot developed rapidly during 1957. Many of the taproots were dead or badly rotted by the end of the first harvest season. Fusarium oxysporum was the major fungus isolated at each location.

The curculio larvae and root rots were most prevalent in plots seeded in June rather than in plots seeded in August. Also, taproots of plants in the Paxton loam were shorter and considerably more branched.

Additional studies are being made to determine the relationship of these insects to the root rot complex and persistence of white clover.

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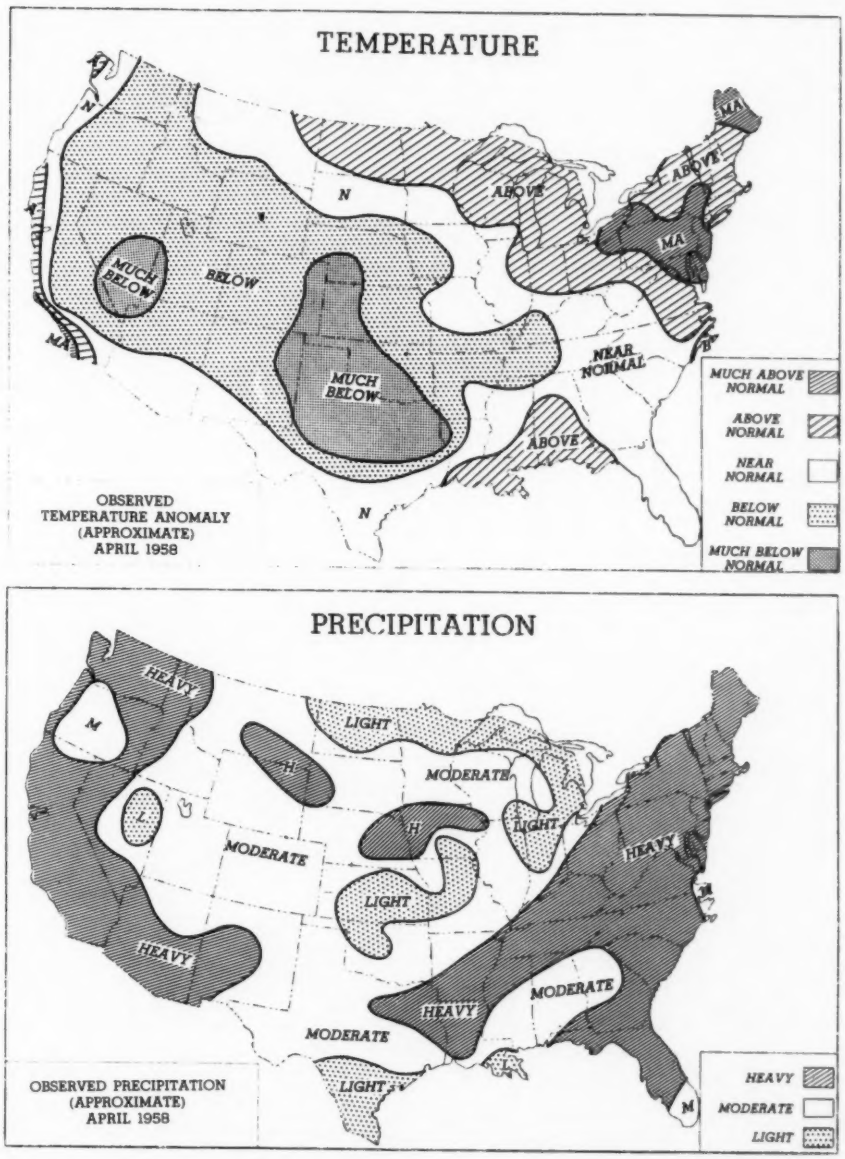
CORRECTIONS

REPORTER, April issue: On page 491, in Immediately after Fruit Harvest paragraph, the last line should read: thiram or ferbam 1 1/2 pounds, Dichlone 1/4 pound, Glyodin 3/4 pint.

REPORTER, April issue: On page 444, first line of fourth paragraph of main text, read Stoller, not Stiller.

REPORTER, April issue: On page 477, in Table 1, the figure for Semesan Bel under 1 min. should be 11.9^{a}, instead of 11.9^{1}, and for Streptomycin sulfate under 15 min. should be 13.6^{a} instead of 13.6^{1}.



The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.